Introduction to Geoprocessing

MIT GIS Services

http://libraries.mit.edu/gis/

Email: gishelp@mit.edu

Listserv for GIS announcements: mitgis@mit.edu

Characteristics of Geographic Information Systems

a. Data

1. Spatial Data - *represents features that have a known location on the earth (vectors and rasters)*

2. Attribute Data – *tabular data*

b. Users / System

1. Data Input – *create or find data*

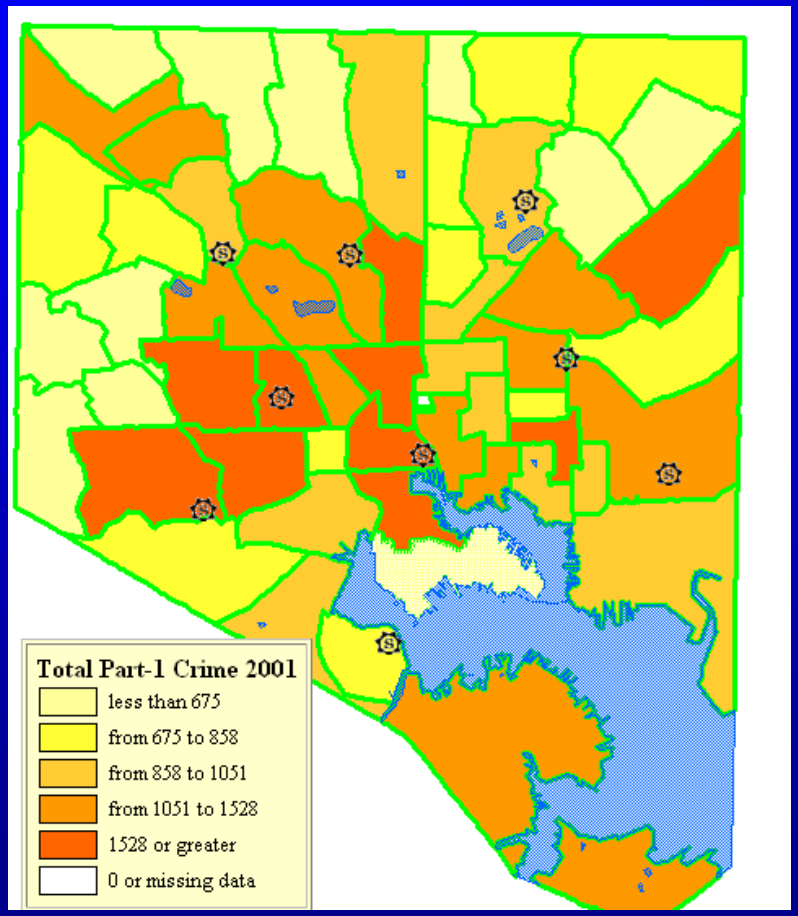
2. Data Management

3. Data Analysis - *answer questions that may not be explicitly stated in the data*

4. Data Output – *maps, new data*

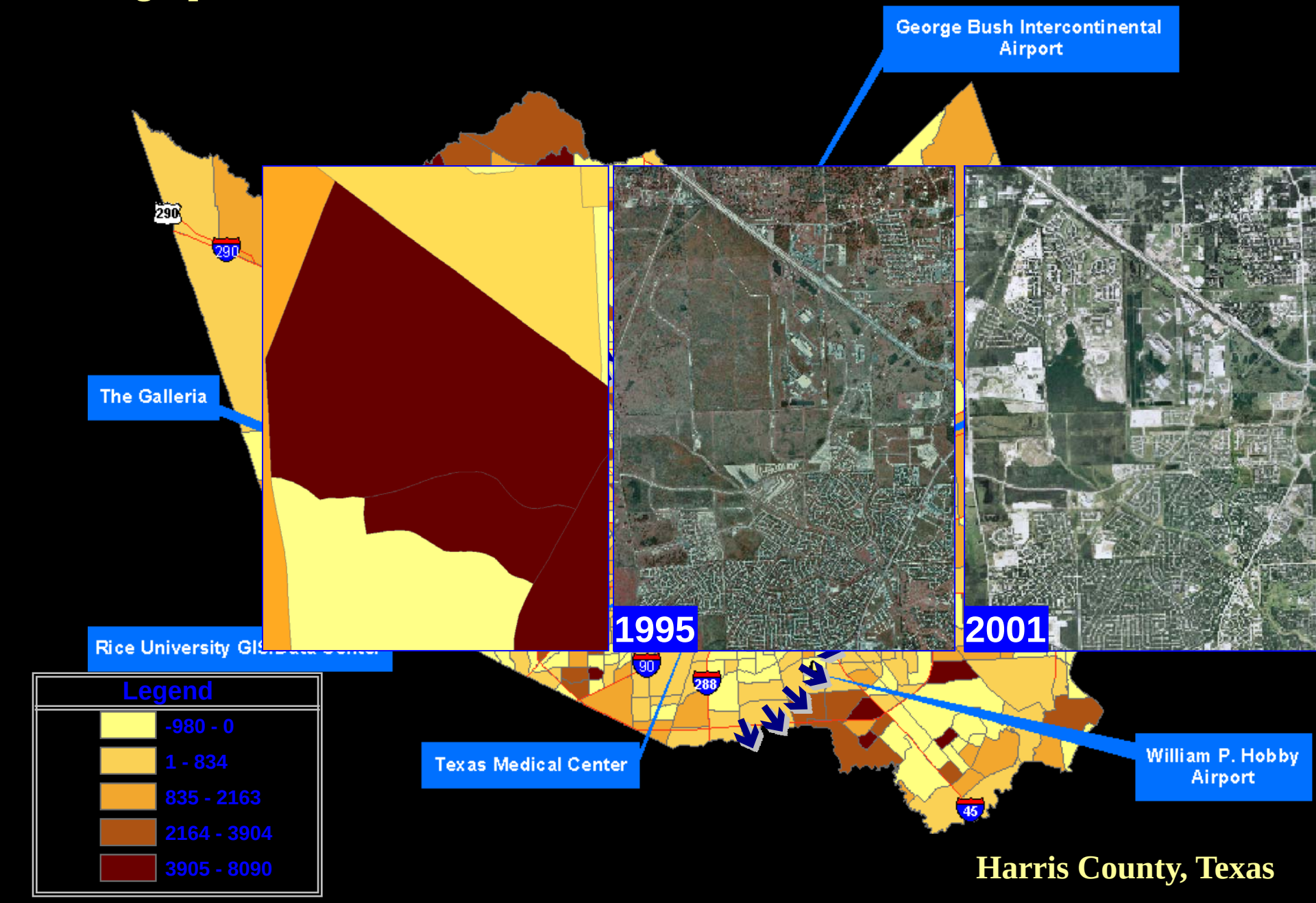
c. Software / Hardware

GIS allows you to ask spatial questions



- Where are the most crimes in Baltimore?
- Where are the police stations?
- Where are crime hotspots?
- Where should I locate a new police station?

Demographic Difference of the Intersects of the 1990 and 2000 Census Tracts



Harris County, Texas

MIT in GIS

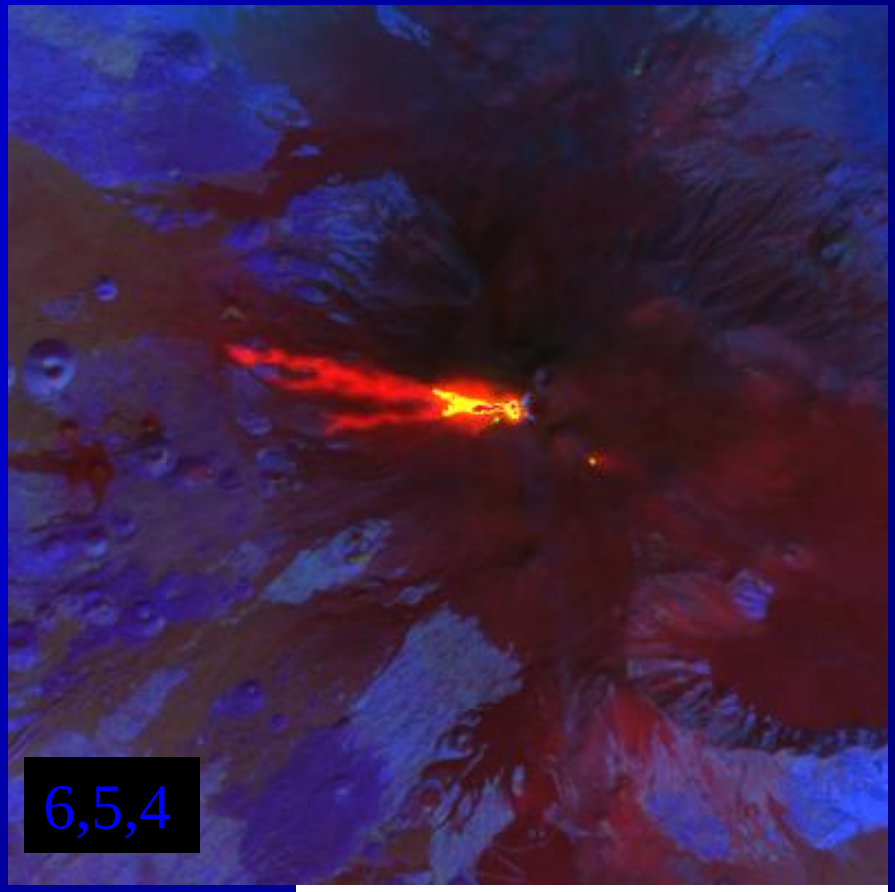
Slide created by Mike Parkin, MIT F&E

City of Cambridge Aerial Photograph
April 2003


City of Cambridge Aerial Photograph
April 2003


City of Cambridge Aerial Photograph
April 2003

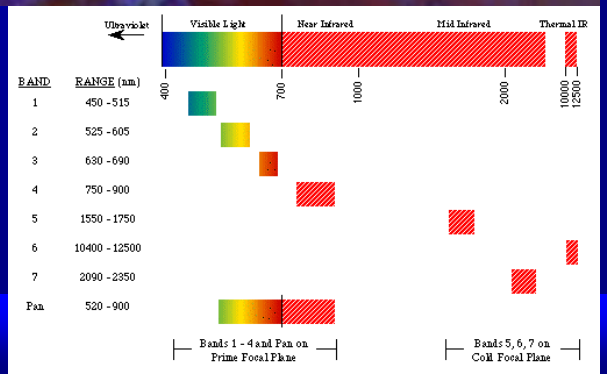
ETM+: Spectral Bands (Band 6 Thermal)



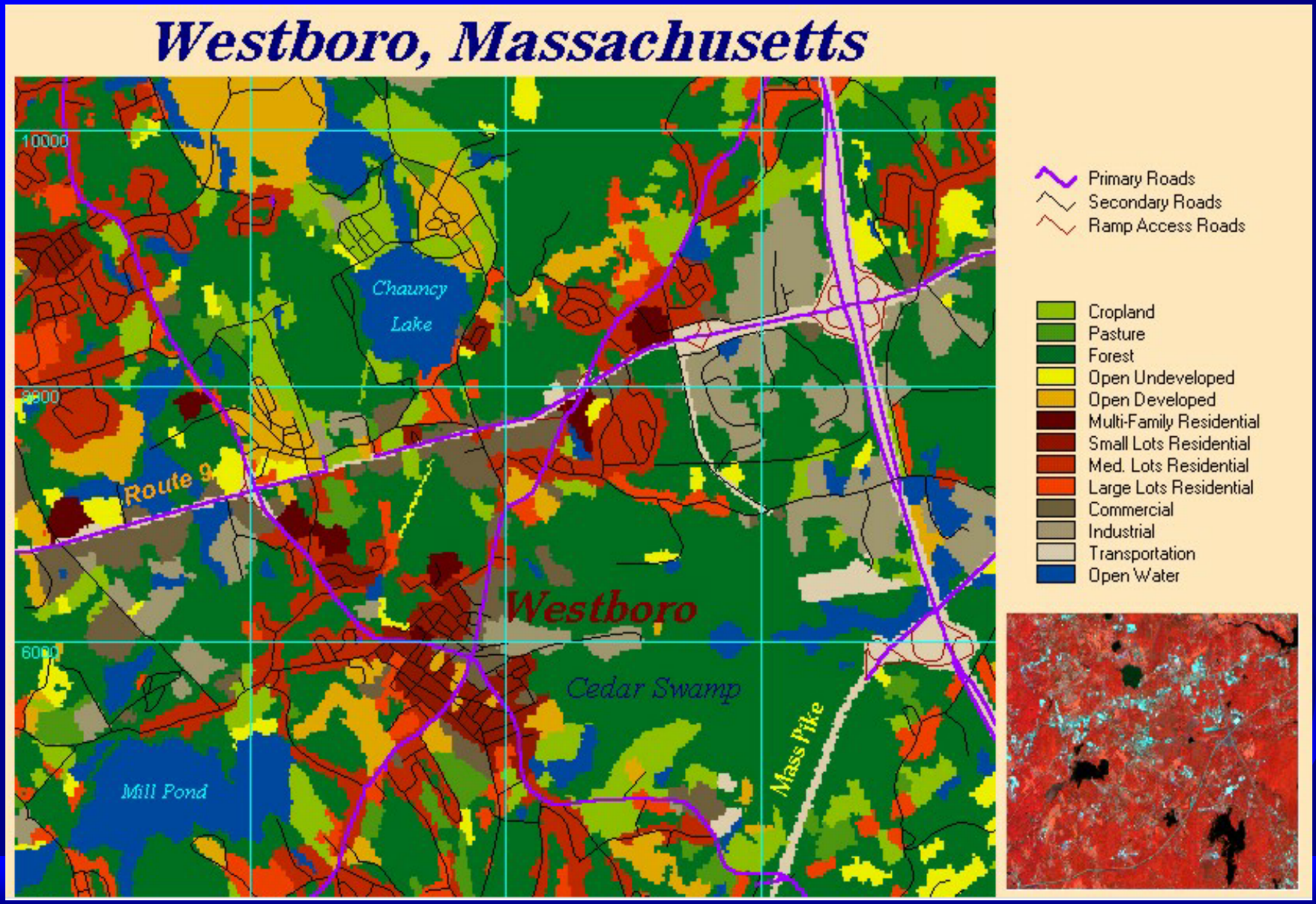
Mt. Etna, Sicily, Italy Bands 321 and 654.

Here Band 6 is Red, Band 5 is Green, Band 4 is Blue.

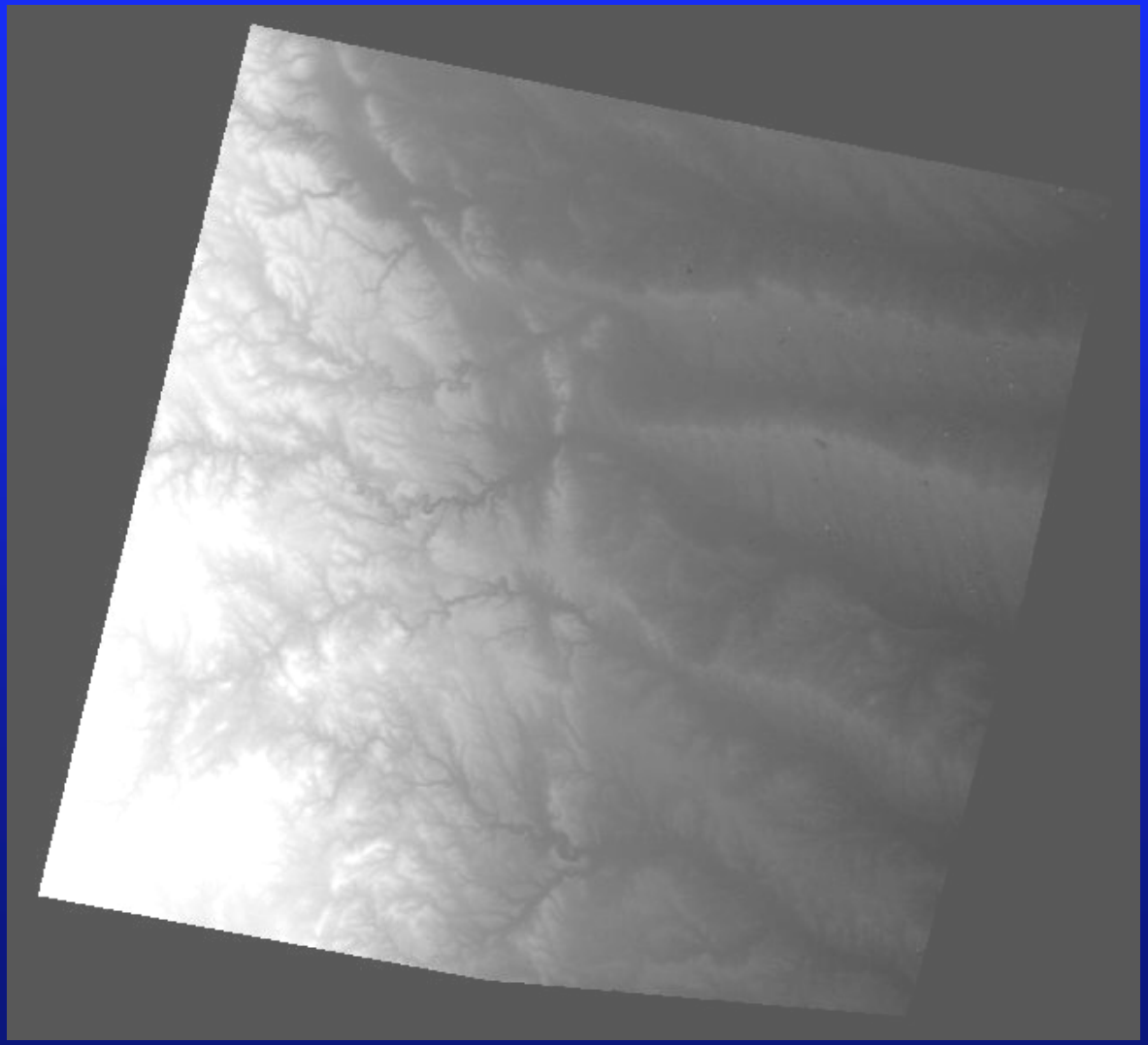
- Notice how the thermal band 6 does not pick up the smoke, or the clouds.
- You can see where the hot lava flows underground in lava tubes.
- The hotter the signal the brighter the pixel.



Land Use / Land Cover



Digital Elevation Model (DEM)



Raster file;

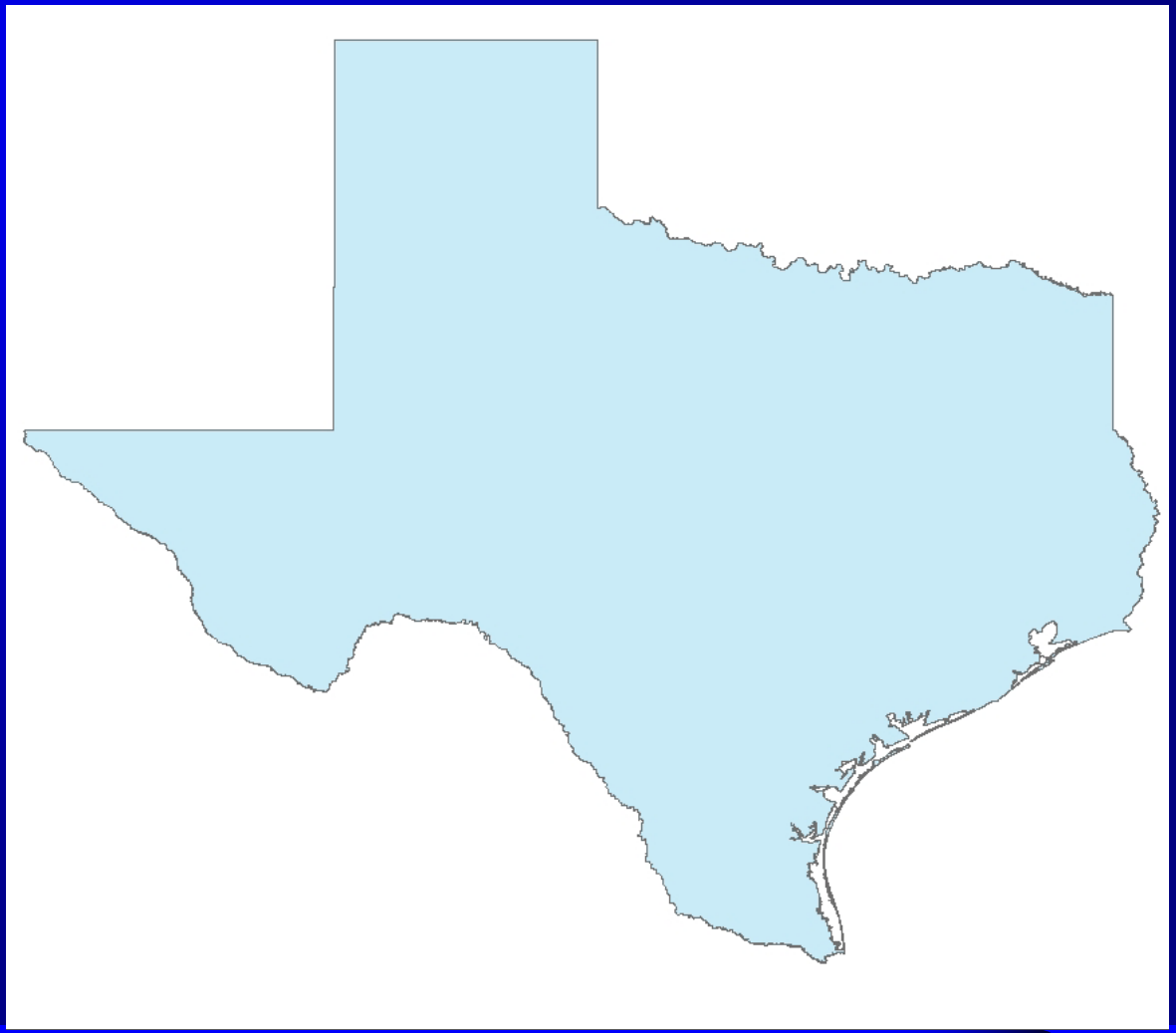
a sampled array of elevations for a number of ground positions at regularly spaced intervals

Cape Town, South Africa
Landsat Image over SRTM DEM

http://photojournal.jpl.nasa.gov/jpegMod/PIA04961_modest.jpg

A computer system to digitally represent geographic objects in a variety of shapes.(Spatial data)

Polygons



A computer system to digitally represent geographic objects in a variety of shapes.(Spatial data)

Polygons

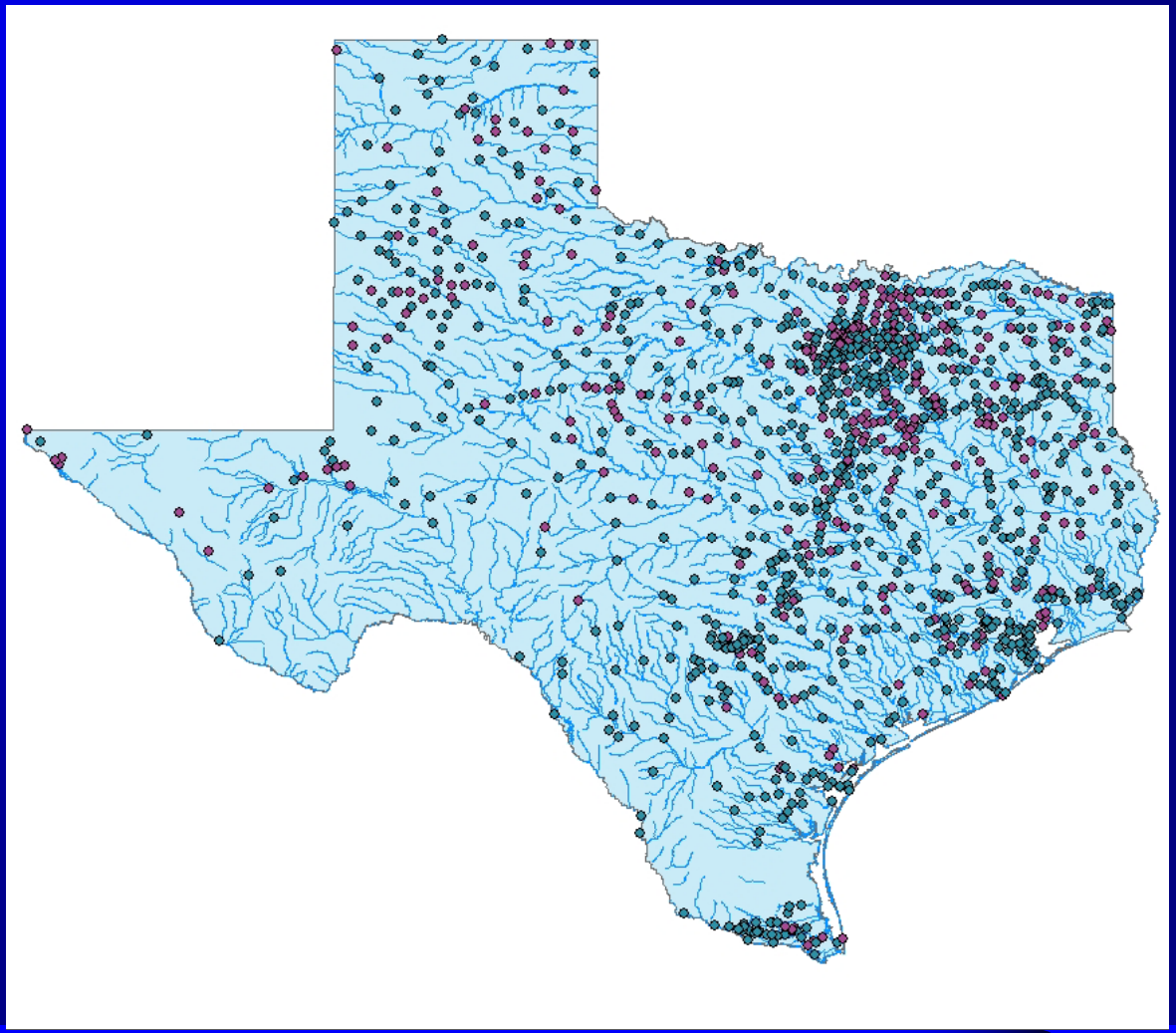
Lines

A computer system to digitally represent geographic objects in a variety of shapes.(Spatial data)

Polygons

Lines

Points



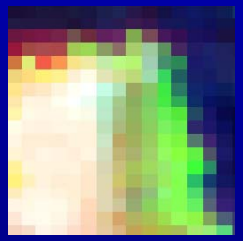
A computer system to digitally represent geographic objects in a variety of shapes.(Spatial data)

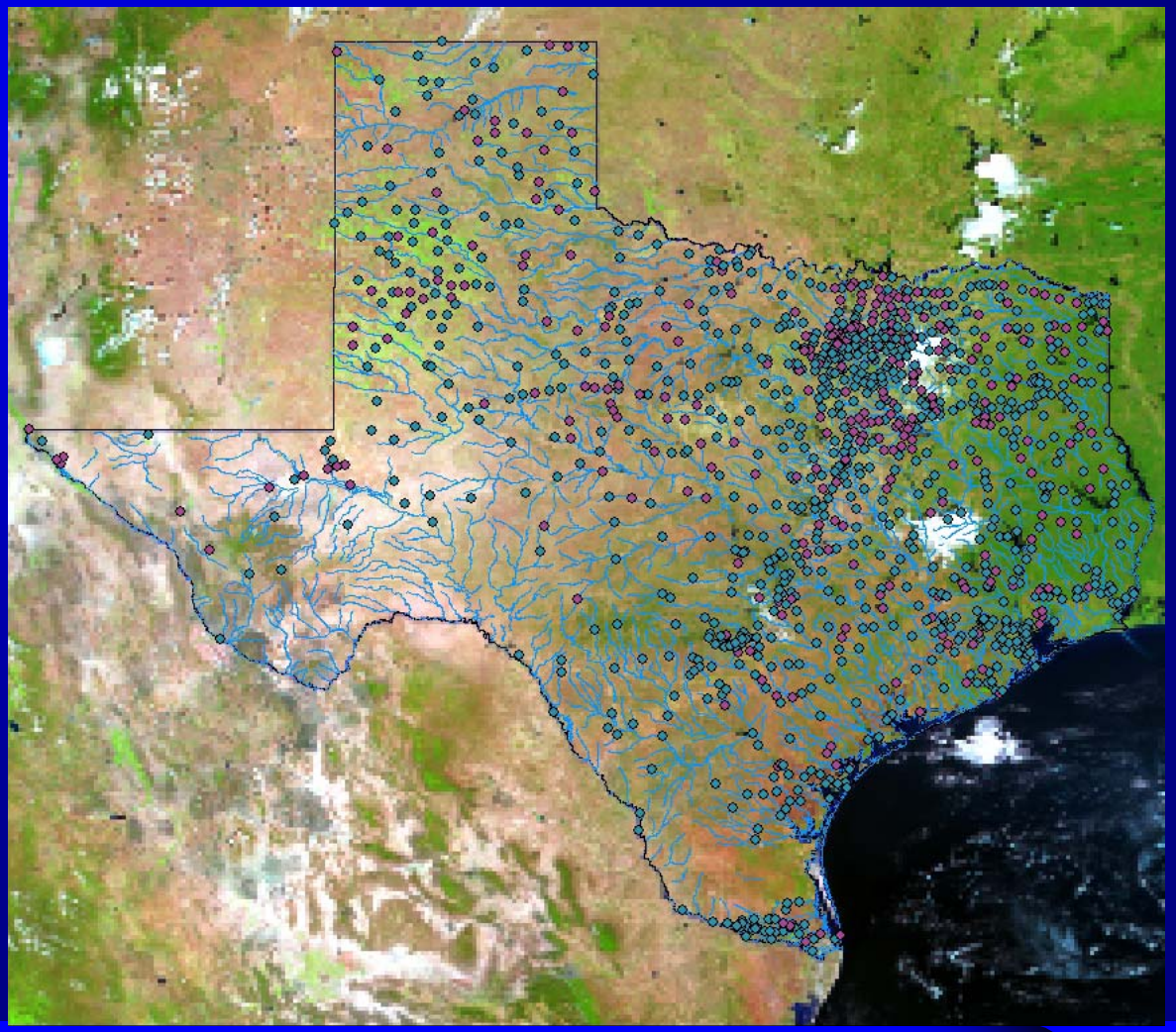
Polygons

Lines

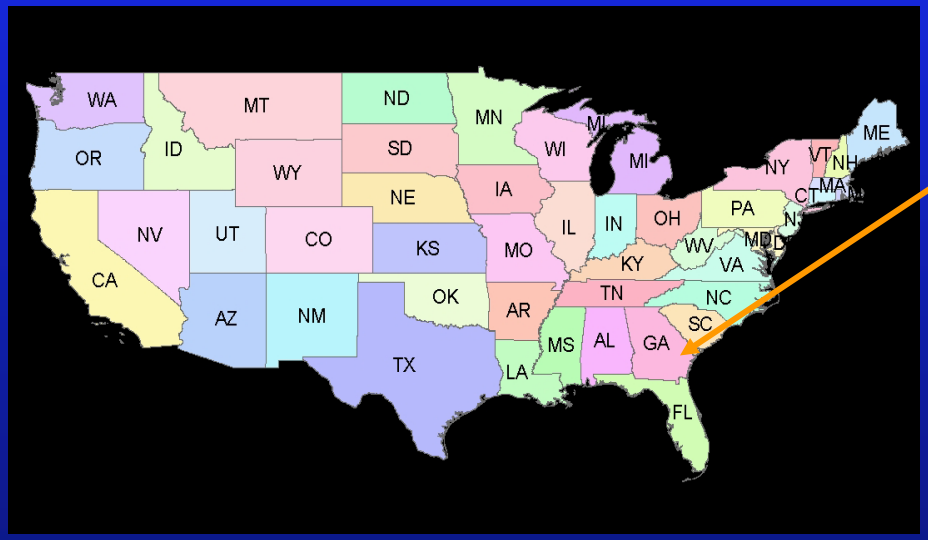
Points

Images (Pixels)





Spatial data have a database backend ("attribute table") that can be used for querying and analysis.

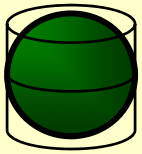


ABBR	NAME	AREA	SUB_REGION	POP1990	POP2000
HI	Hawaii	6428.217	Pacific	1108229	1184688
AL	Alabama	51655.693	E S Cen	4040587	4395481
AK	Alaska	579209.198	Pacific	550043	624523
AZ	Arizona	114000.360	Mtn	3665228	4894006
AR	Arkansas	53178.652	W S Cen	2350725	2566938
CA	California	158096.781	Pacific	29760021	33603430
CO	Colorado	104091.253	Mtn	3294394	4139027
CT	Connecticut	4975.458	N Eng	3287116	3289062
DE	Delaware	2012.514	S Atl	666168	762227
DC	District of Columbia	68.342	S Atl	606900	513618
FL	Florida	56616.254	S Atl	12937926	15341185
GA	Georgia	58830.269	S Atl	6478216	7950119
ID	Idaho	83570.060	Mtn	1006749	1273309
IL	Illinois	56339.384	E N Cen	11430602	12187552
IN	Indiana	36182.311	E N Cen	5544159	5979311
IA	Iowa	56271.701	W N Cen	2776755	2877060
KS	Kansas	82276.988	W N Cen	2477574	2672387
KY	Kentucky	40409.048	E S Cen	3685296	3988695
LA	Louisiana	46738.807	W S Cen	4219973	4386033
ME	Maine	32495.312	N Eng	1227928	1257219
MD	Maryland	9996.506	S Atl	4781468	5212902
MA	Massachusetts	8118.475	N Eng	6016425	6206482
MI	Michigan	58099.340	E N Cen	9295297	9907530
MN	Minnesota	84383.092	W N Cen	4375099	4820250
MS	Mississippi	47664.922	E S Cen	2573216	2788415
MO	Missouri	69704.423	W N Cen	5117073	5502243
MT	Montana	147043.116	Mtn	799065	885795

Each spatial attribute is referenced in a projection and a coordinate system.

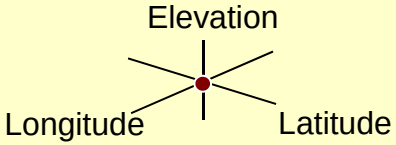
PROJECTION

A method of representing the earth's three-dimensional surface as a flat two-dimensional surface.



COORDINATE SYSTEM

A fixed reference framework superimposed onto the surface of an area to designate the position of a point within it; Common coordinate systems are geographic (three-dimensional), in which locations are measured in degrees of latitude and longitude, and planar (also called Cartesian), in which the earth's surface is projected onto a two-dimensional plane and locations are measured in meters or feet.



29º 43' 7.10 " N
95º 23' 55.74" W
GCS_WGS_1984

1/2m Aerial Photo

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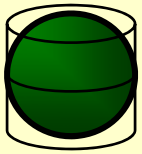

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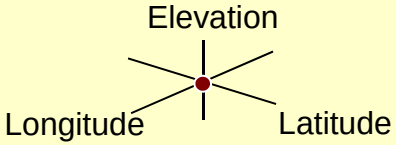

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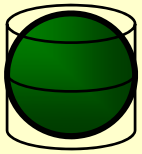

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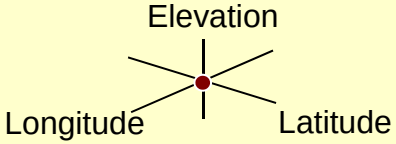

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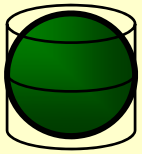

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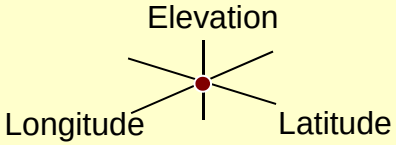

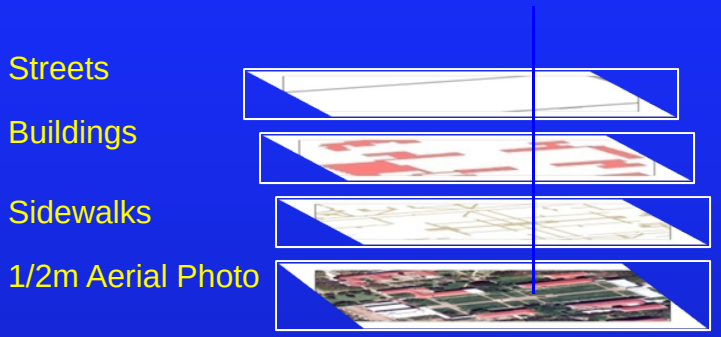

29º 43' 7.10 " N
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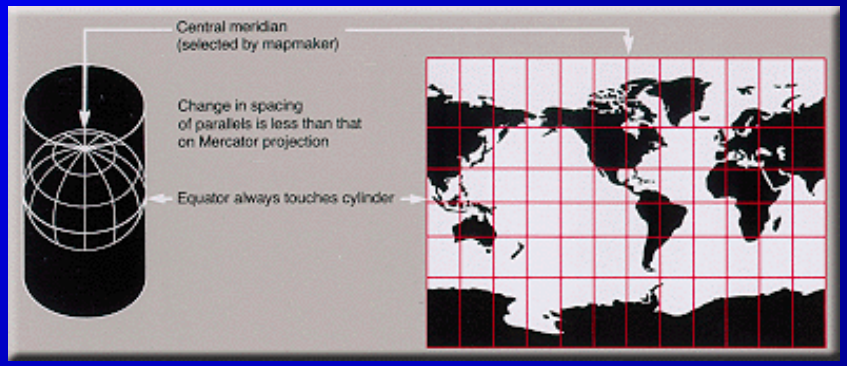
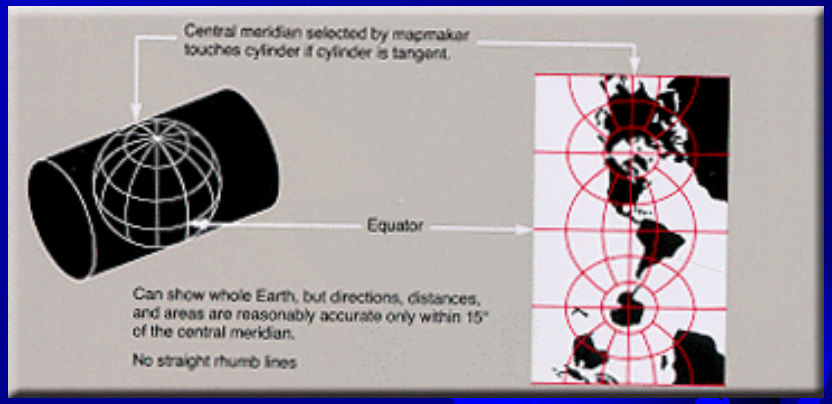
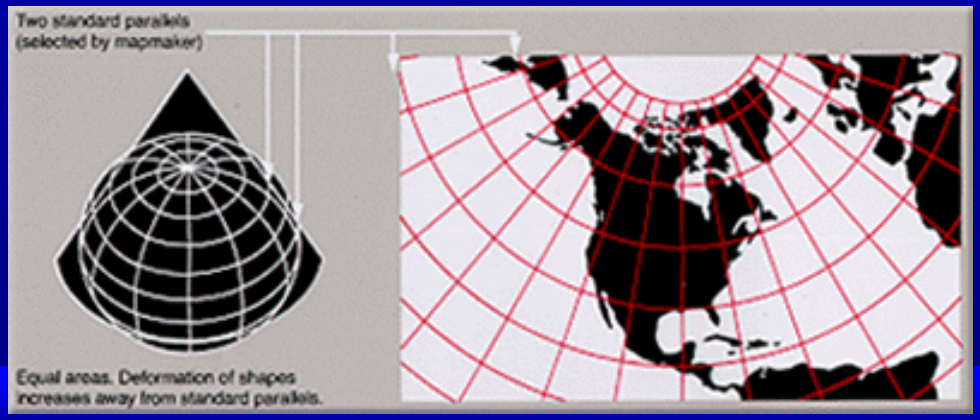
Map projections

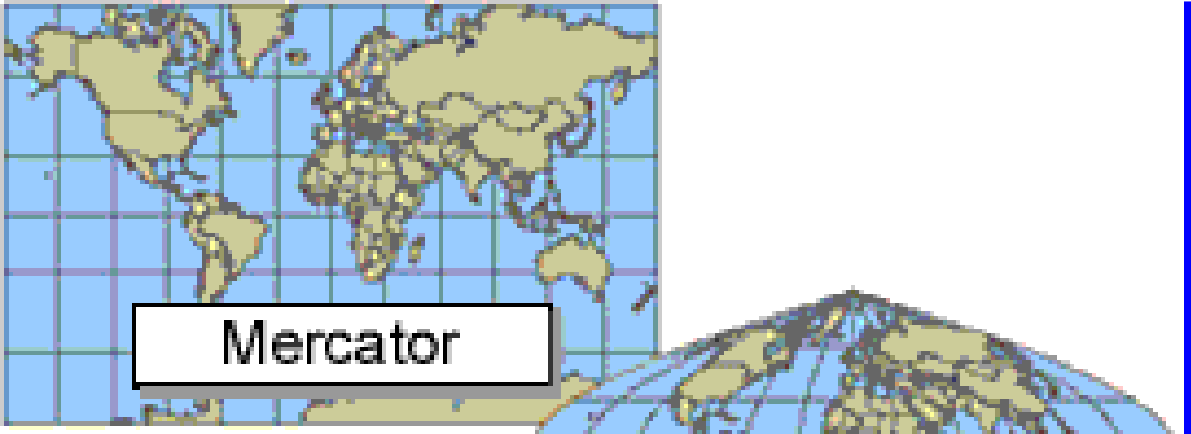
There are many different map projections. All map projections distort

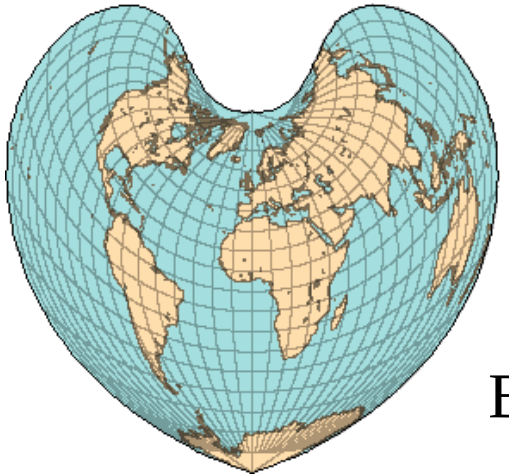
- shape
- area
- distance
- or
- direction









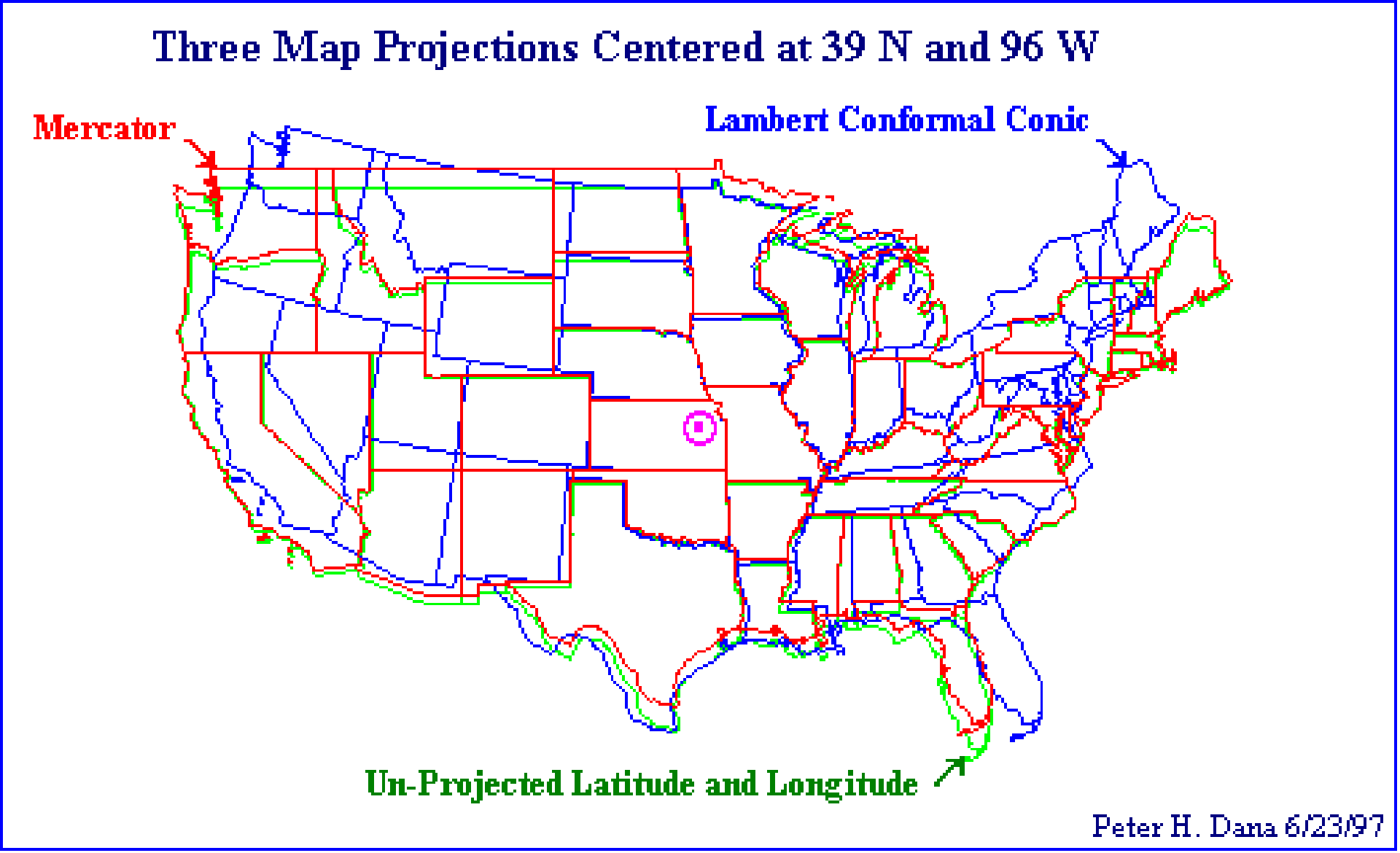


Bonne

The Mercator projection maintains shape and direction.

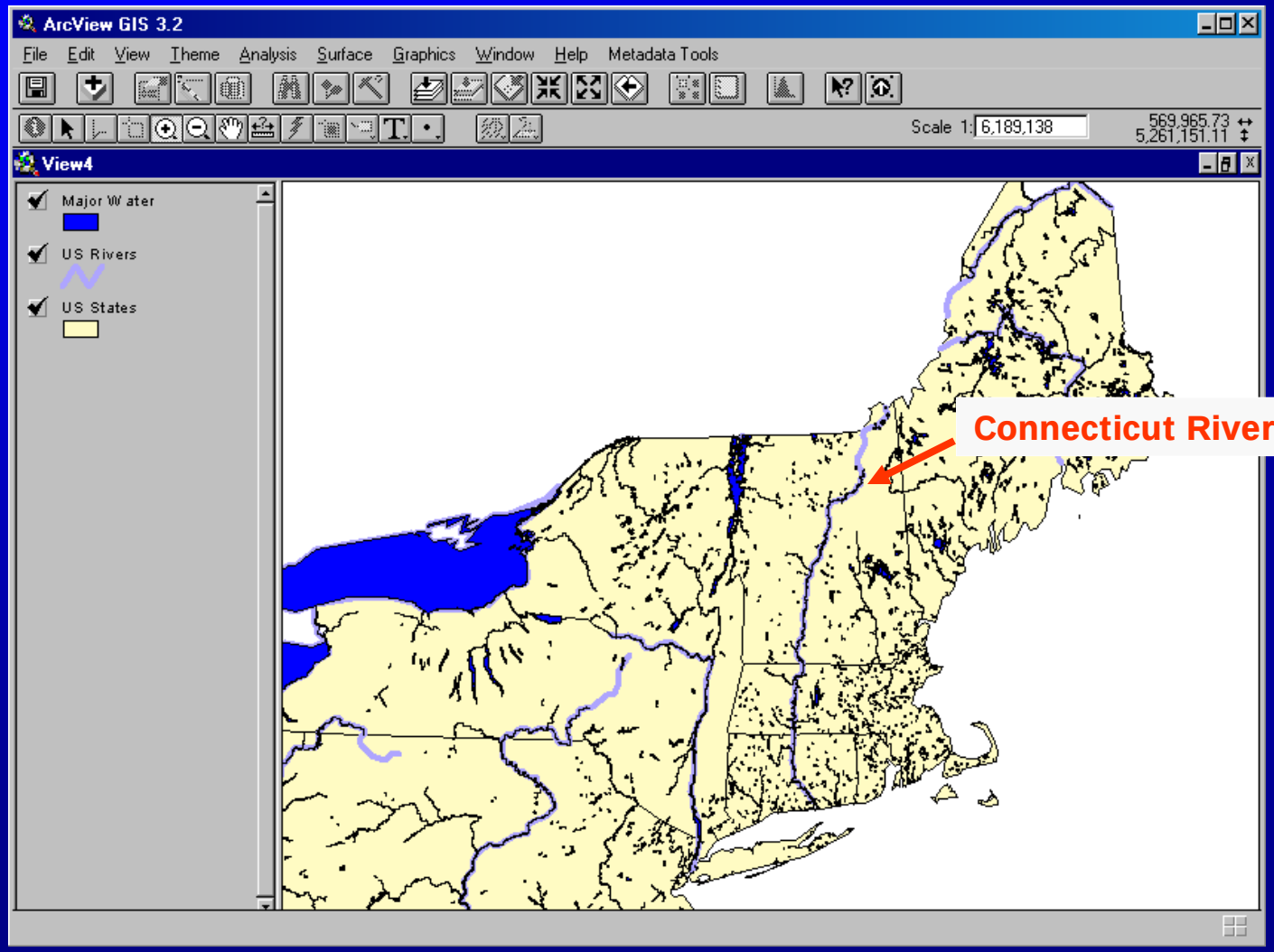
The Sinusoidal and Peters projections both maintain area, but look quite different from each other.

The Robinson projection does not enforce any specific properties but is widely
used because it makes the earth’s surface and its features "look right."



"Three Different Map Projections" from The Geographer's Craft, Map Projections webpage: http://www.colorado.edu/geography/gcraft/notes/mapproj/mapproj_f.html

Projection Problem Illustration



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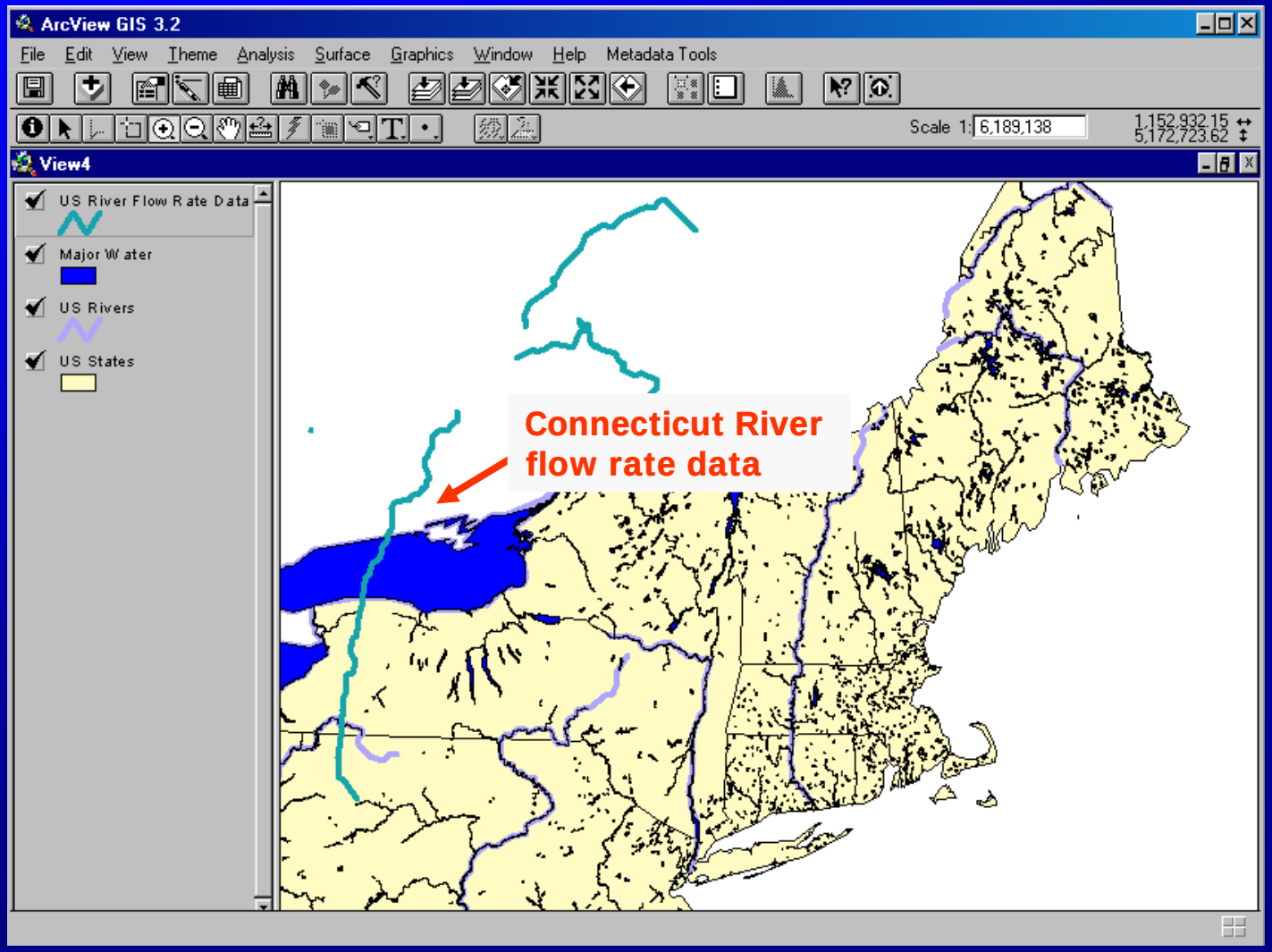

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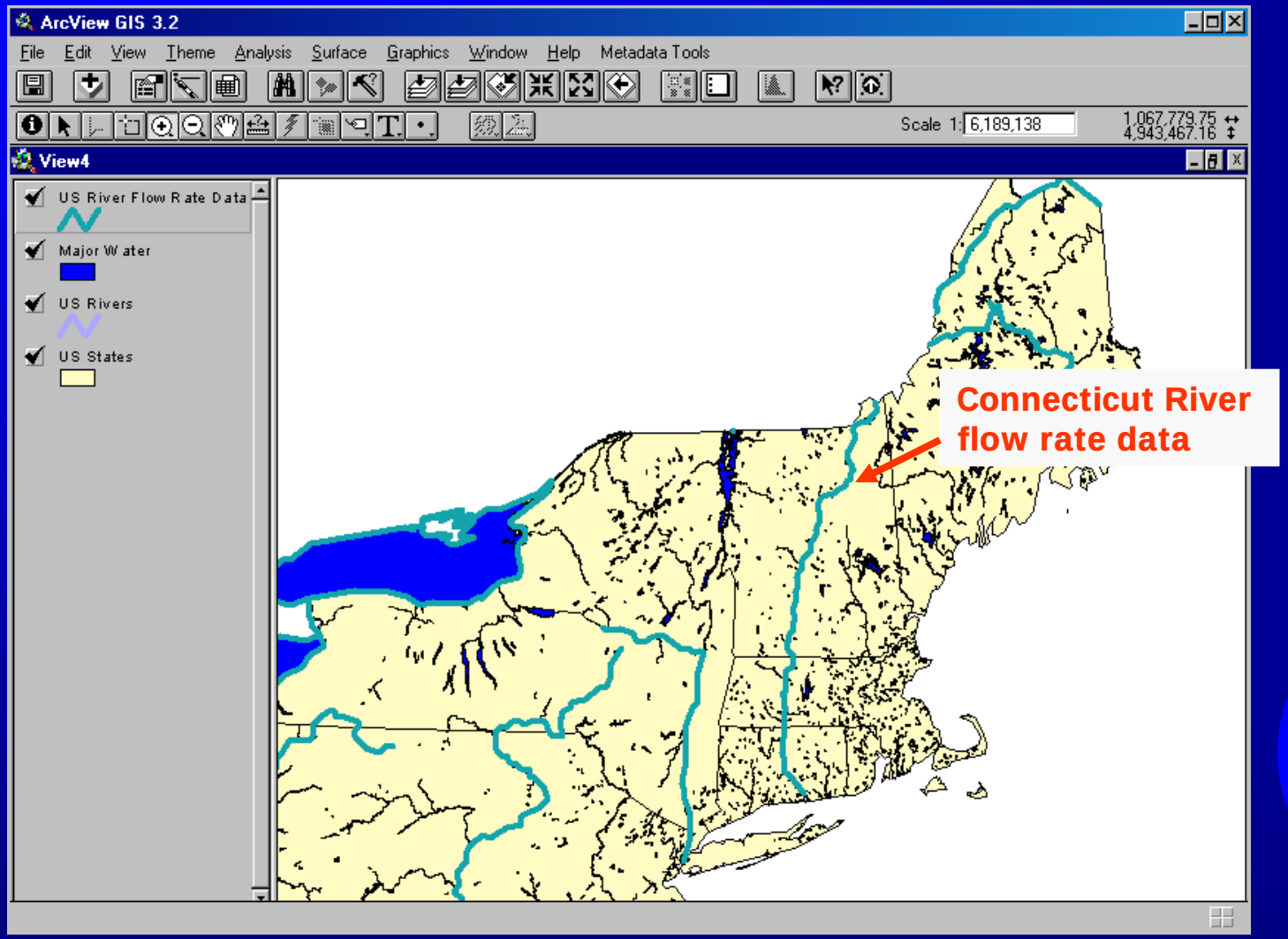


Data Types - Tabular

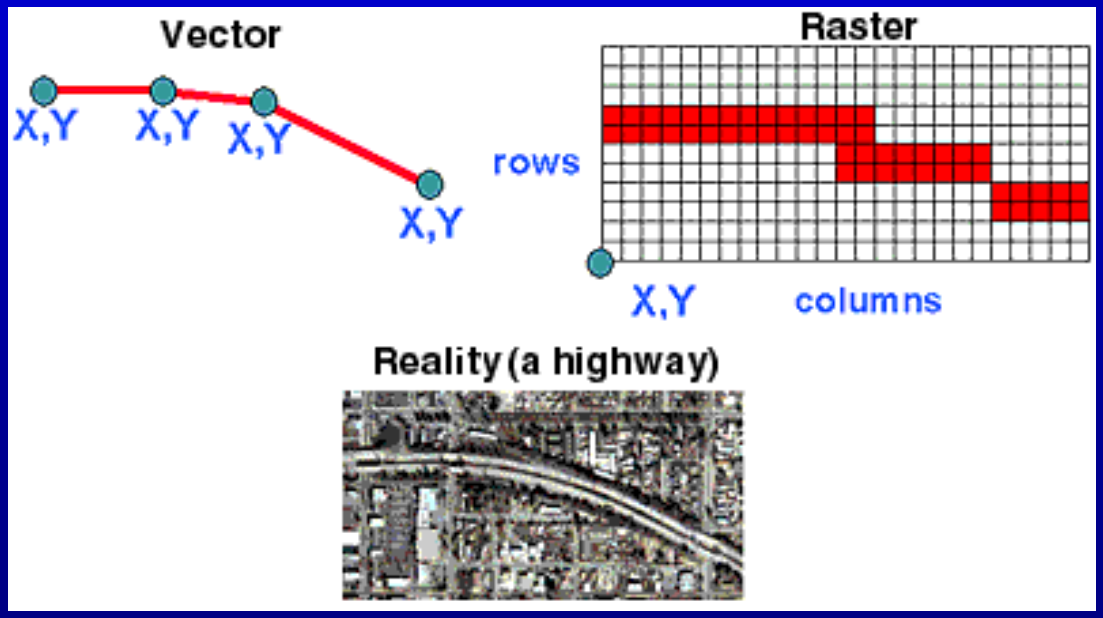
- Table (CSV, Excel) or database (Access, Oracle, PostgreSQL)
- Join with spatial data file by common attribute (state, county, etc)
- Mapped as points using coordinate points such as latitude and longitude gathered from a GPS
- Geocode: associate address field with GIS street file

Data Types – Spatial Data

Spatial or coordinate data represents features that have a known location on the earth.

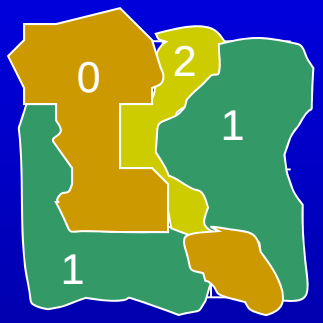
Vector: Points, Lines and Polygons

Raster: Row and column matrix



Data Types – Spatial Data - Vector

Vector: Points, lines and polygons



Attributes of Theme2.shp

Shape	ID	LANDUSE
Polygon	0	WATER
Polygon	1	HIGHLAND
Polygon	2	WETLAND

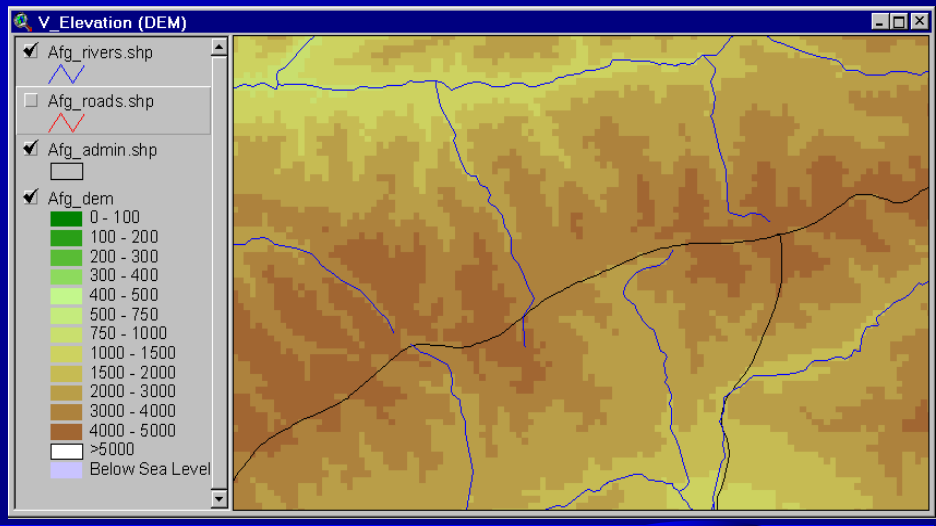
Data Types – Spatial Data - Raster

A raster is a model of the world as a surface that is divided into a regular grid of cells, arranged into rows and columns. All cells (or pixels) must be the same size.

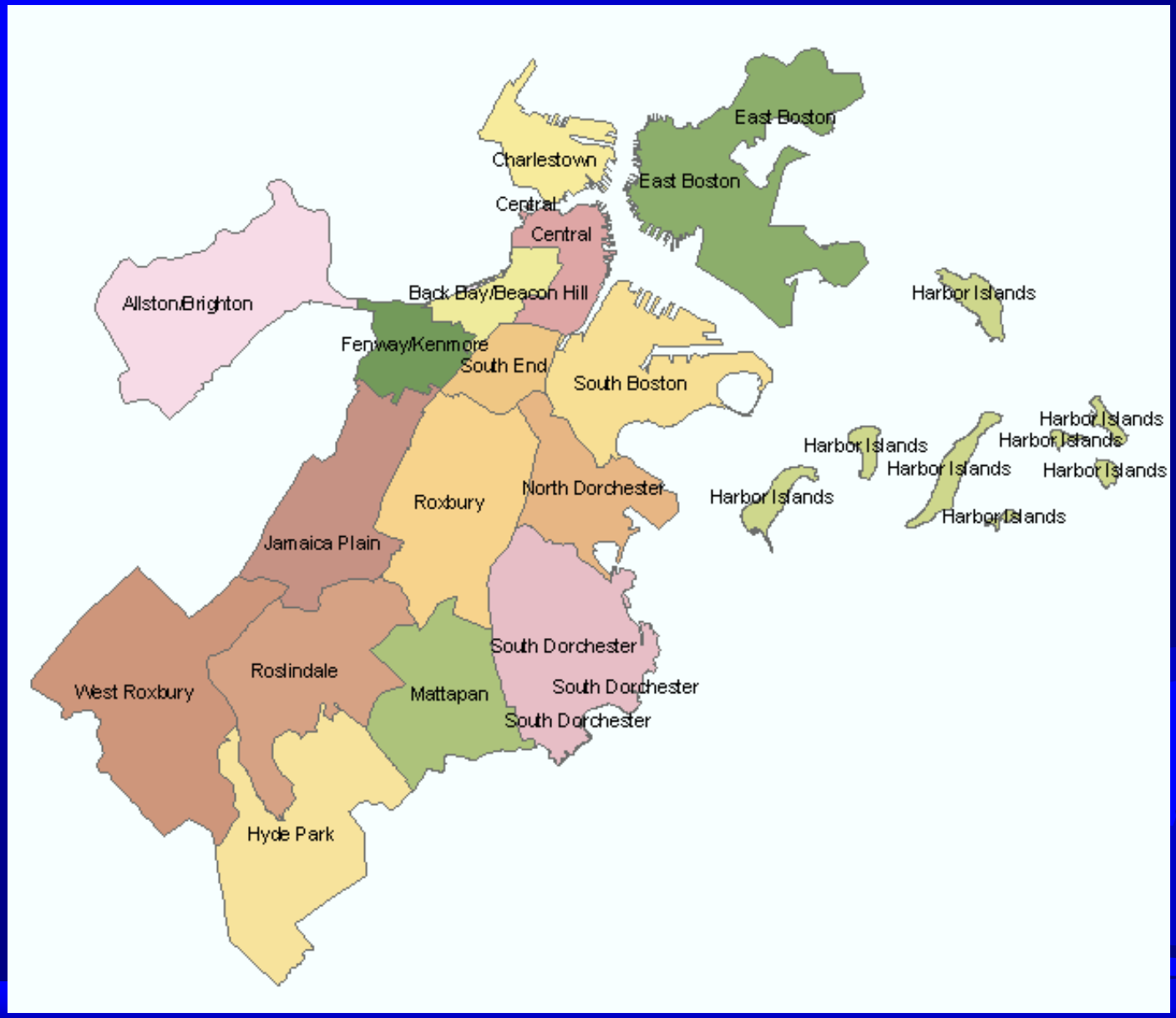
- images (such as aerial photographs)
- grids (derived data representing continuous values such as an elevation surface or categories such as vegetation types)

0	0	0	2	1	1
1	0	2	1	1	1
1	0	0	2	1	1
1	1	1	1	0	1

0 : WATER
1 : HIGHLAND
2 : WETLAND



Tabular, Vector, or Raster?



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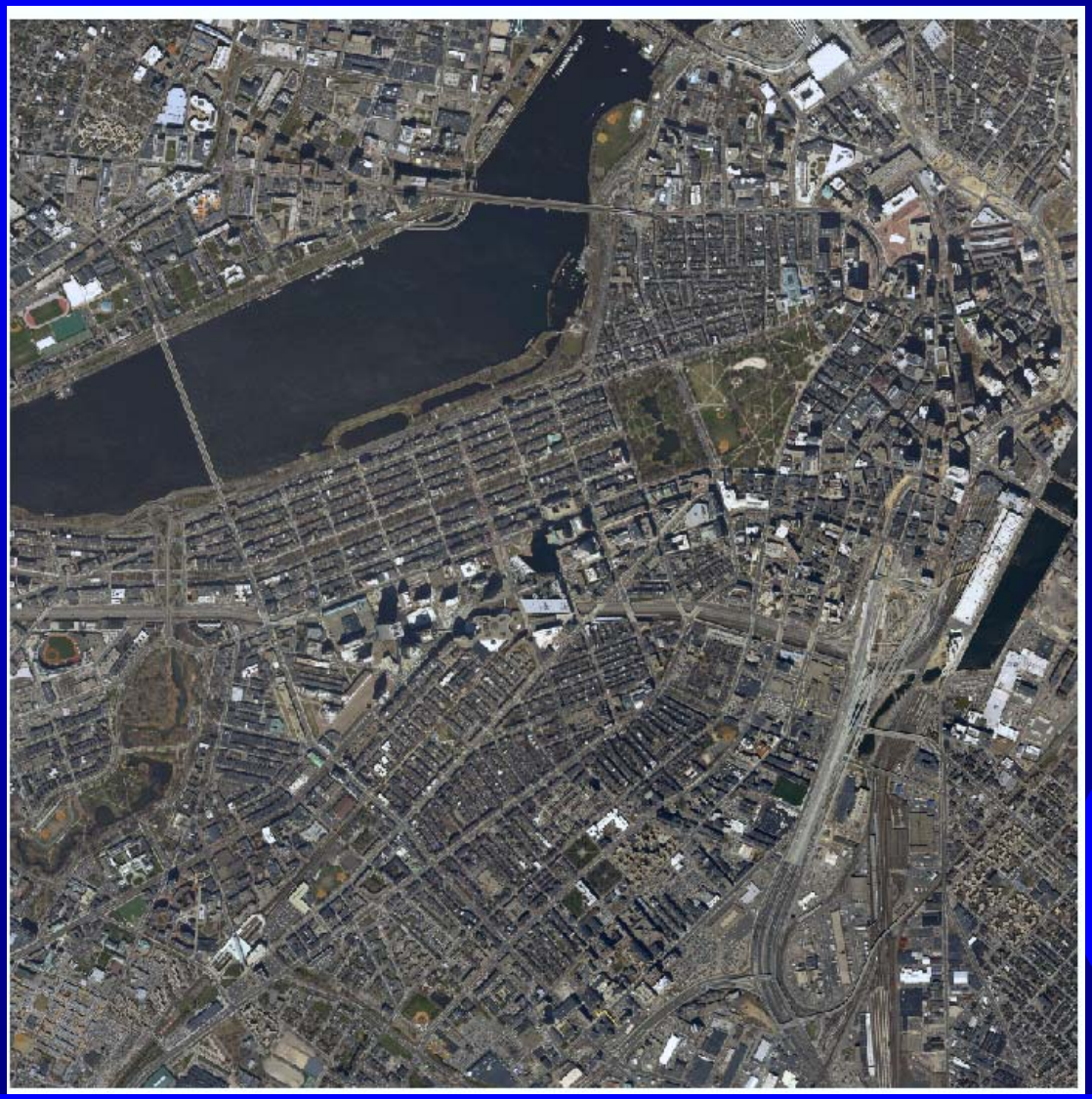


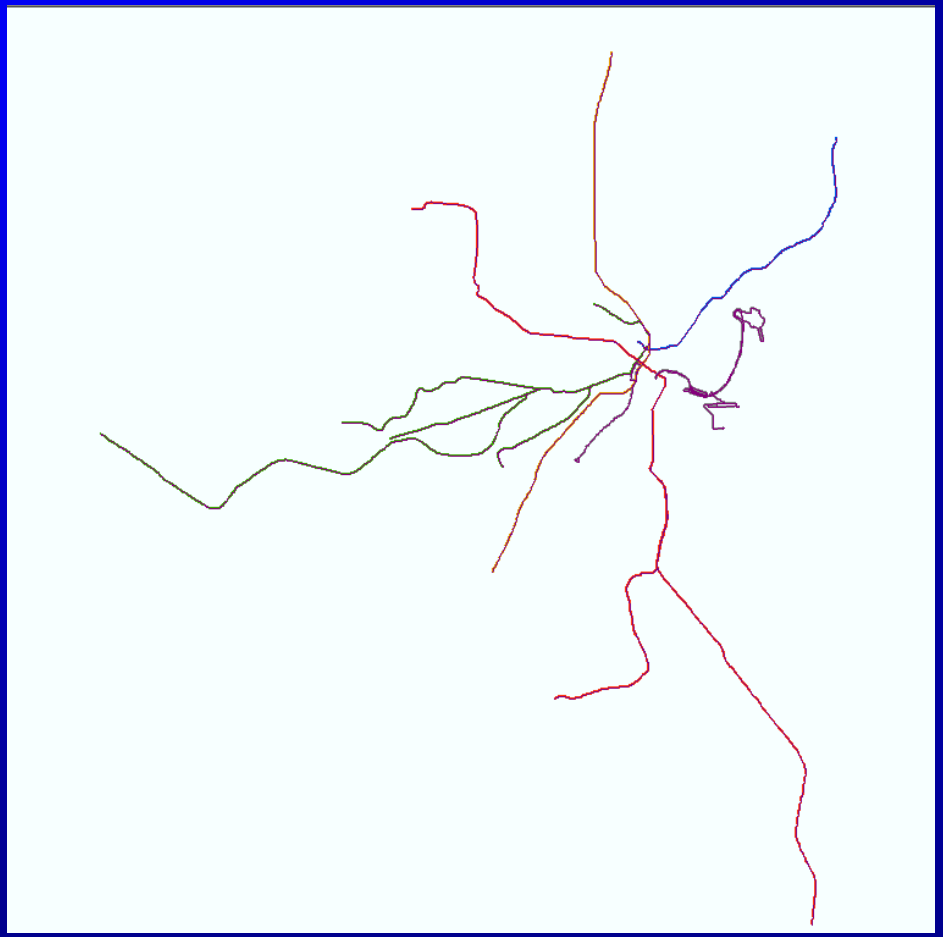
Tabular, Vector, or Raster?

Attributes of allegany_usgsnames

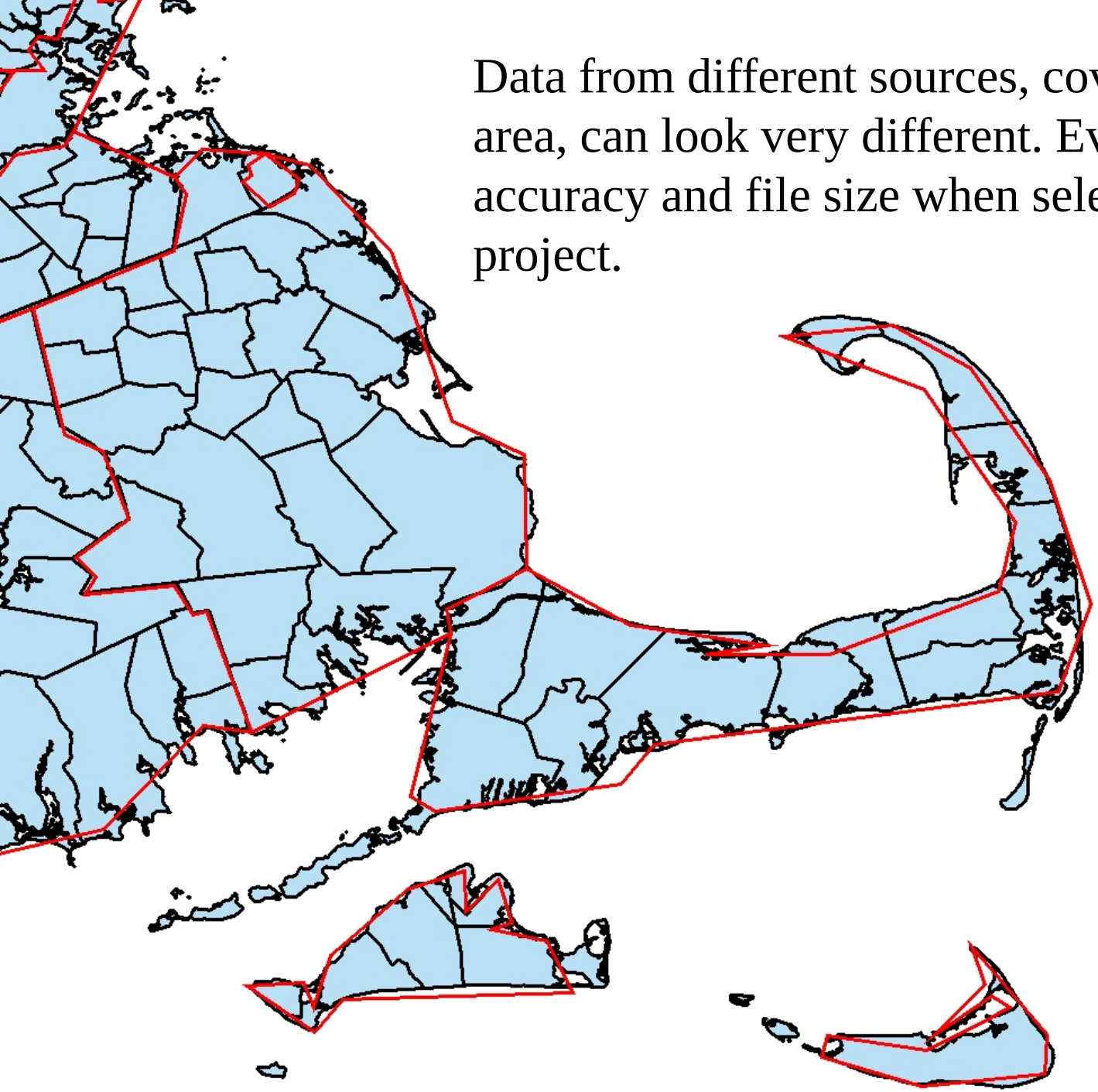
OID	FEATURE_ID	FEATURE_NA	FEATURE_CL	STATE_ALPH	STATE_NUME	COUNTY_NAM	COUNTY_NUM	PRIMARY_LA	PRIMA
0	586762	Ragged Mountain	Summit	MD	24	Allegany	1	394309N	078294
1	586905	Rocky Gap Run	Stream	MD	24	Allegany	1	394221N	078415
2	587360	Shriver Ridge	Ridge	MD	24	Allegany	1	394306N	078423
3	587361	Sideling Hill Creek	Stream	MD	24	Allegany	1	393817N	078200
4	587847	Town Creek	Stream	MD	24	Allegany	1	393133N	078323
5	587848	Town Hill	Range	MD	24	Allegany	1	394329N	078224
6	588433	Wills Creek	Stream	MD	24	Allegany	1	393856N	078455
7	590175	Evitts Mountain	Summit	MD	24	Allegany	1	394313N	078393
8	590749	Martin Mountain	Summit	MD	24	Allegany	1	394202N	078375
9	595217	Youghiogheny River	Stream	PA	42	Allegheny	3	402115N	079521
10	583083	Bear Camp Branch	Stream	MD	24	Allegany	1	394244N	078264
11	583976	Crooked Run	Stream	MD	24	Allegany	1	394424N	078212
12	584310	Evitts Creek	Stream	MD	24	Allegany	1	393729N	078442
13	584372	Fifteenmile Creek	Stream	MD	24	Allegany	1	393727N	078230
14	584748	Green Ridge	Ridge	MD	24	Allegany	1	394218N	078253
15	586524	Pine Ridge	Ridge	MD	24	Allegany	1	394313N	078415
16	942214	Ainsworth Brook	Stream	NY	36	Allegany	3	415944N	077490
17	943495	Bee Hollow	Valley	NY	36	Allegany	3	415902N	078132
18	943629	Bells Brook	Stream	NY	36	Allegany	3	420000N	078180
19	947882	Cryder Creek	Stream	NY	36	Allegany	3	415953N	077521
20	948880	Dutton Hollow	Valley	NY	36	Allegany	3	420030N	078021
21	953133	Honeoye Creek	Stream	NY	36	Allegany	3	415806N	078114
22	953229	Horse Run	Stream	NY	36	Allegany	3	415839N	078132
23	955541	Little Genesee Creek	Stream	NY	36	Allegany	3	415943N	078151

Record: 1 Show: All Selected Records (0 out of 3942 Selected) Options

Tabular, Vector, or Raster?



Data from different sources, covering the same area, can look very different. Evaluate scale, accuracy and file size when selecting data for a project.



Where to Get GIS Data

1. MIT Geodata Repository (http://libraries.mit.edu/gis/data)
   - GeoWeb – use any web browser
   - MIT Geodata Search Tool for ArcGIS software

2. MIT GIS Lab

   Use Barton to search the collection of data on CD's and DVD's
   http://library.mit.edu/F/?func=file&file_name=find-a&local_base=GIS

3. Internet

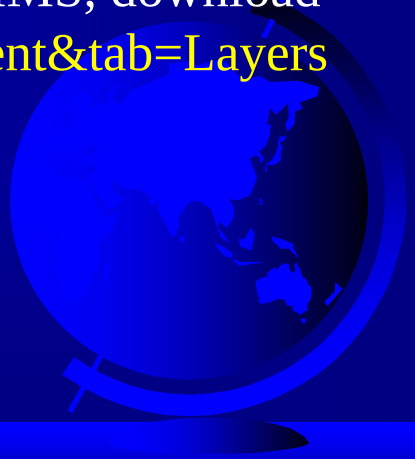
   http://libraries.mit.edu/gis/data/
   http://lyceum.massgis.state.ma.us/wiki/ - WMS, WFS, ArcIMS, download
   http://resources.esri.com/arcgisdesktop/index.cfm?fa=content&tab=Layers

4. Create your own

   GPS, Digitize, etc.

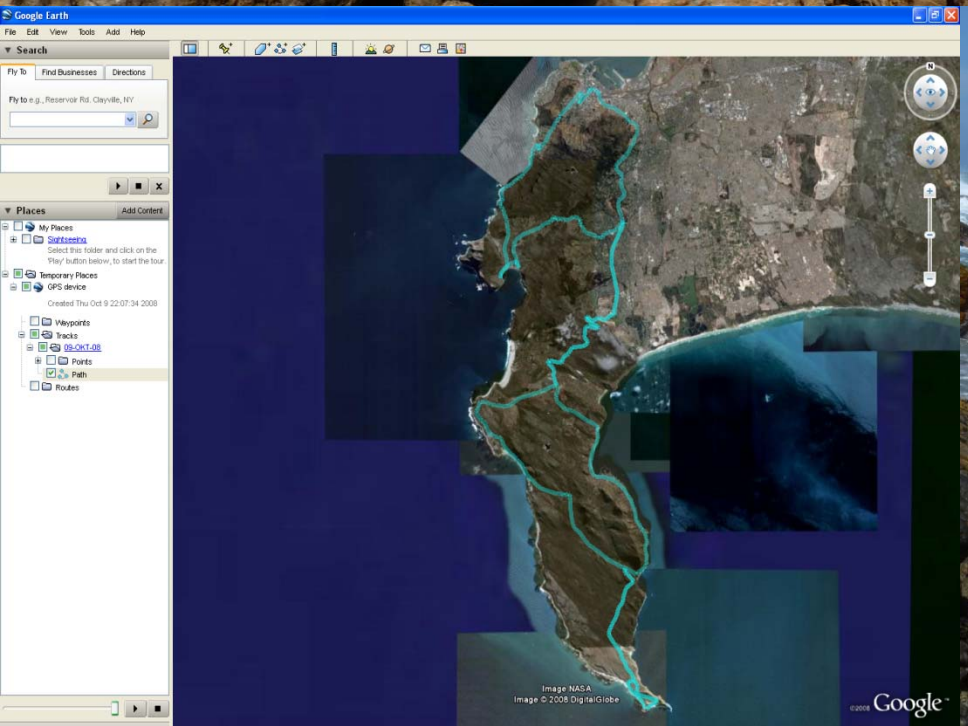
Not finding what you want? GIS data purchase requests?

Contact gishelp@mit.edu



Collect your own data.

Global Positioning Systems (GPS) are available for checkout from the Rotch Library Circulation desk



Census

The libraries and GIS Serivces can help you with:

- Navigating through the sea of data to find what you want
- Providing tools to increase access and ease of use
- Mapping demographics
- Providing historical print records for Massachusetts

http://libraries.mit.edu/guides/types/census/tools-overview.html

Overview of Demographic Mapping Tools

	Geolytics	Social Explorer	MIT Census Tool in ArcGIS	Census Website	ICPSR
Mapping Tools	Simple to use Easy to bring maps into GIS system.	Simple online mapping interface	Simple tool inside ArcGIS	Limited pre-set web tools in American Factfinder	None

Social Science Data Services

Offers assistance with finding social science data, such as:

Economic Development	Labor
Economic Indicators	Political Science and Government
Finance	Public Opinion
Health	Social Surveys
Industry	Trade Statistics: International & U.S.

and statistical software and methodology consultations.

http://libraries.mit.edu/guides/subjects/data/

- Available in Dewey Library

Data Formats

ArcGIS can read many formats including:

- Shapefile, geodatabase, coverage, grid
- Image formats (*JPG*, *TIF*, *geotif*)
- CAD (*DXF & DWG*)
- Google Earth (*KML*, *KMZ*) can be read in ArcGlobe
  - (turn on KML toolbar)

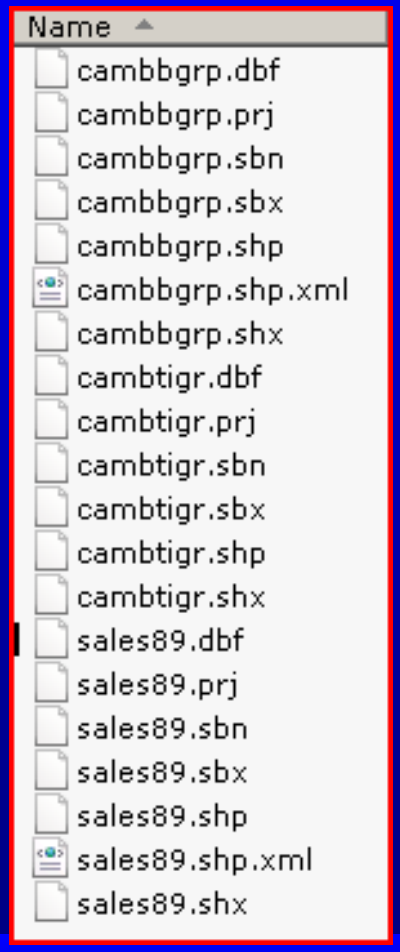
Data can be exported from ArcGIS to a variety of formats including:

Use ArcToolbox Conversion tools

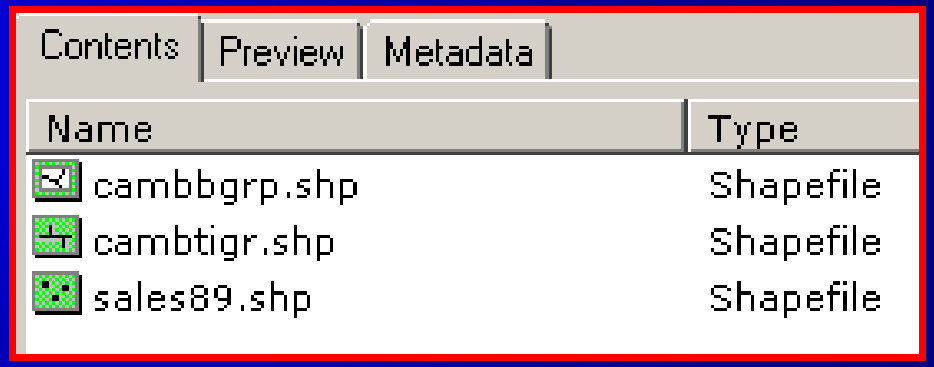
- Google Earth *(.KML, .KMZ)*
- CAD *(.DWG, .DXF, .DGN)*
- Adobe Illustrator *(.AI)*
- TIF
- JPG

Shapefiles

Windows Explorer



ArcCatalog



Shapefiles are bundles of files that must be kept together!

GIS Desktop Software

Open Source

- GRASS GIS
- OSSIM *
- Quantum GIS
- gvSIG *

(in incubation)*

Proprietary

- ESRI ArcGIS Desktop
- MapInfo

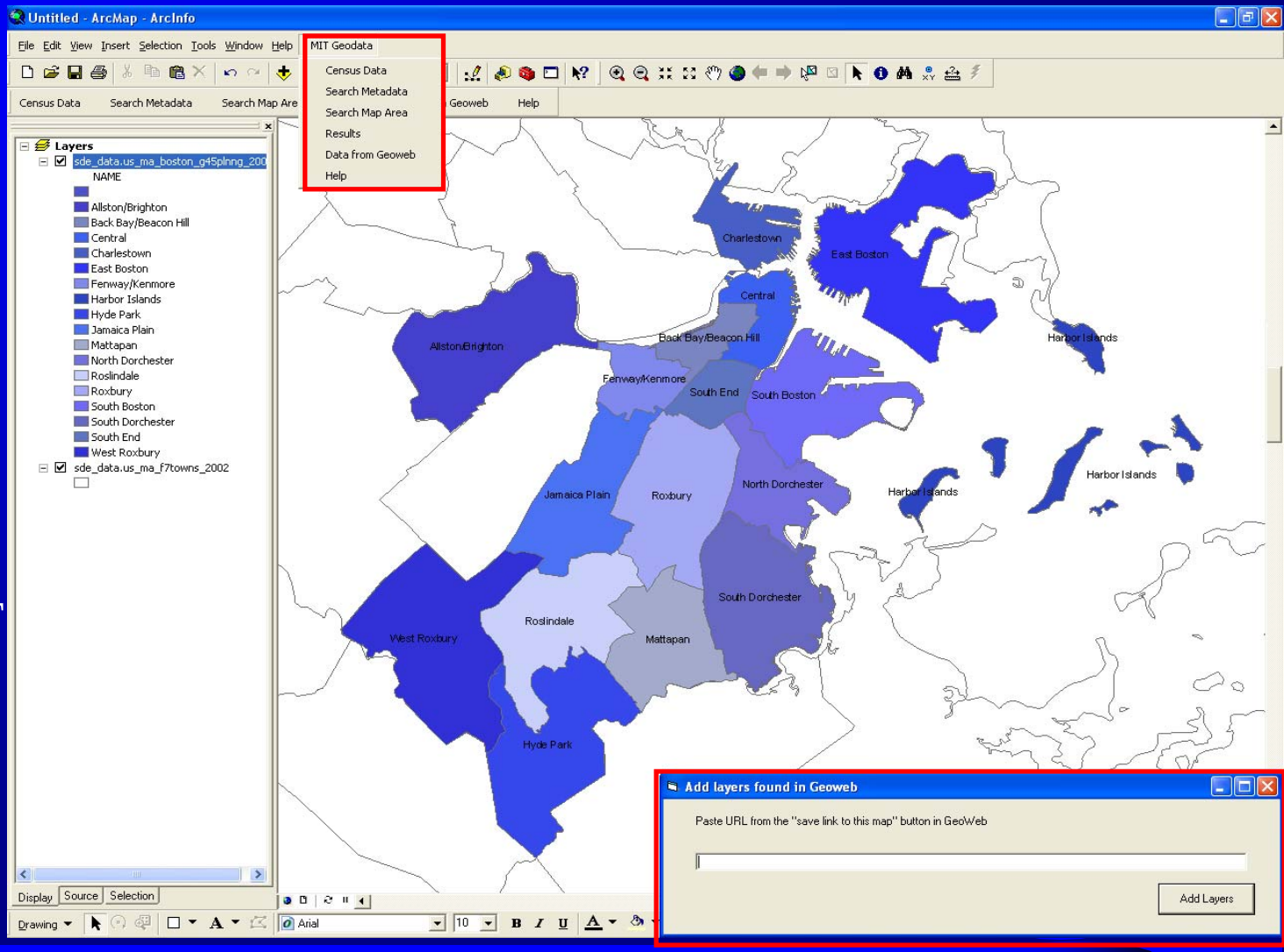
Open Source means the source code is made available under a license that allows the modification, and re-distribution of the software at will. For a more in-depth definition visit the Open Source Initiative: http://opensource.org/docs/definition.php

For more information about open source projects visit OSGEO – the Open Source Geospatial Foundation website: http://osgeo.org

For a longer list of GIS software visit: http://en.wikipedia.org/wiki/List_of_GIS_software

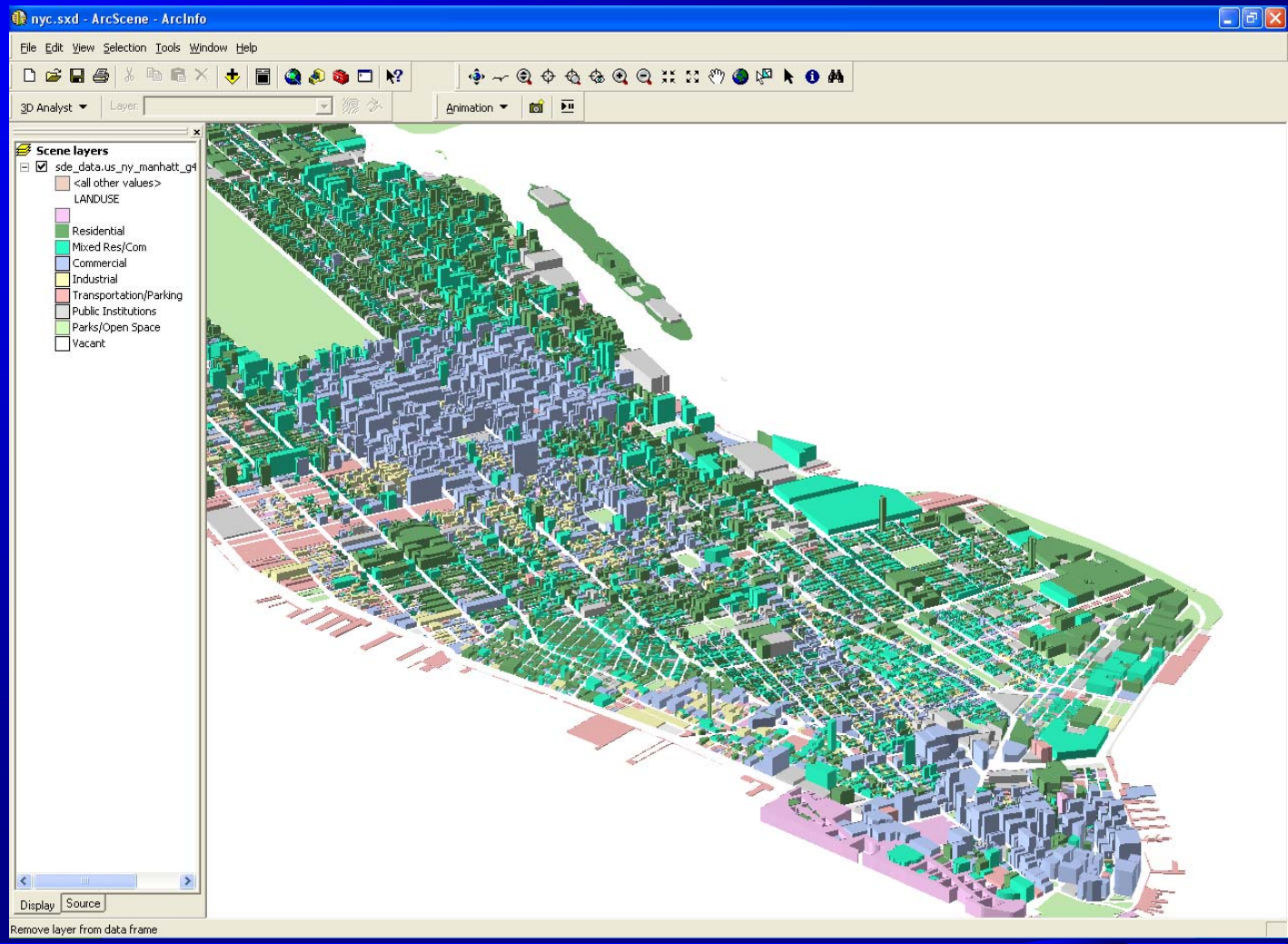
ArcGIS - ArcMap

- Provides the most tools for processing data, doing analysis and creating maps
- Work in 2D
- Use MIT created tools for easily accessing the MIT Geodata Repository with a full GIS software package



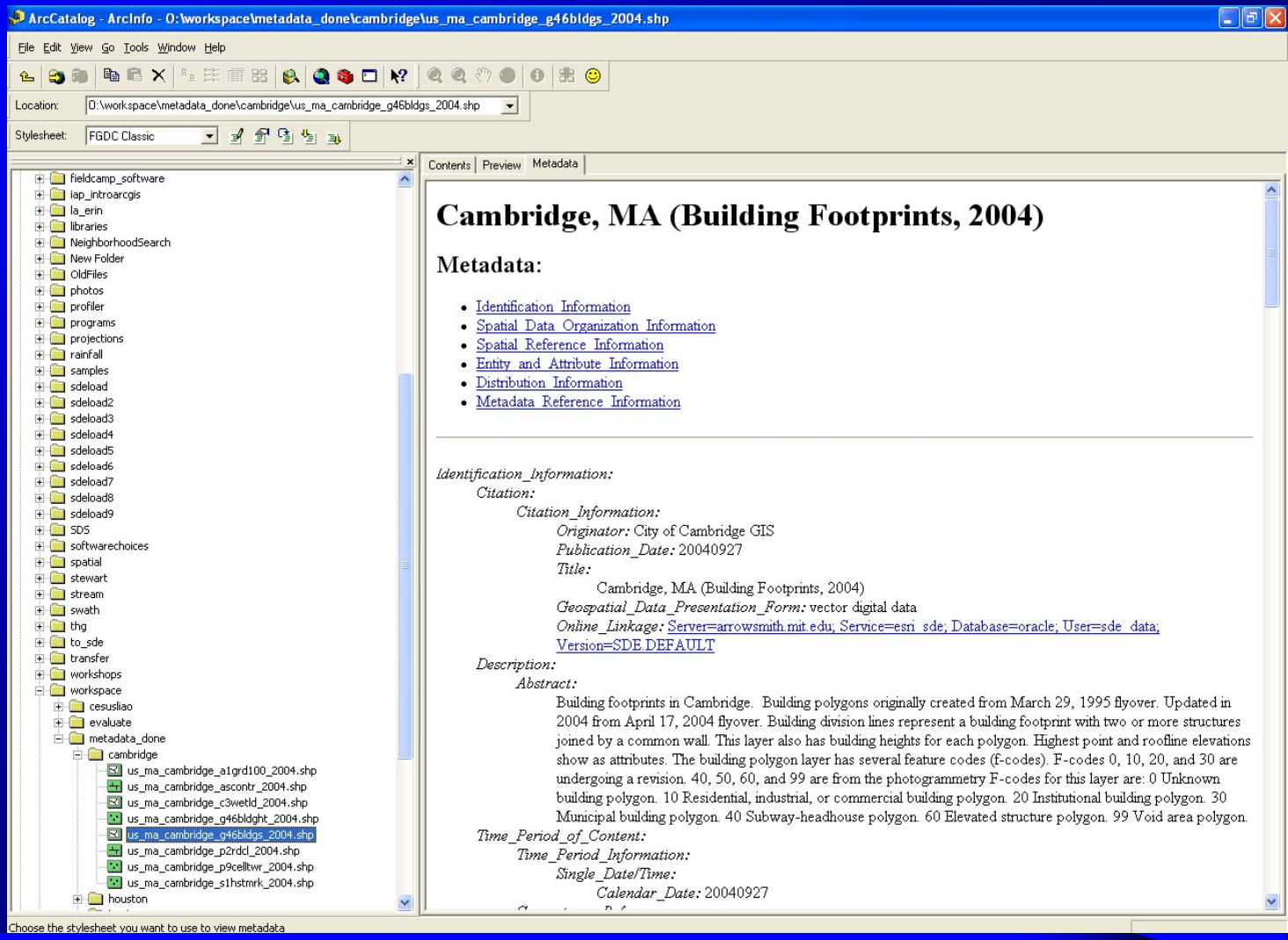
ArcGIS - ArcScene

Work in 3D



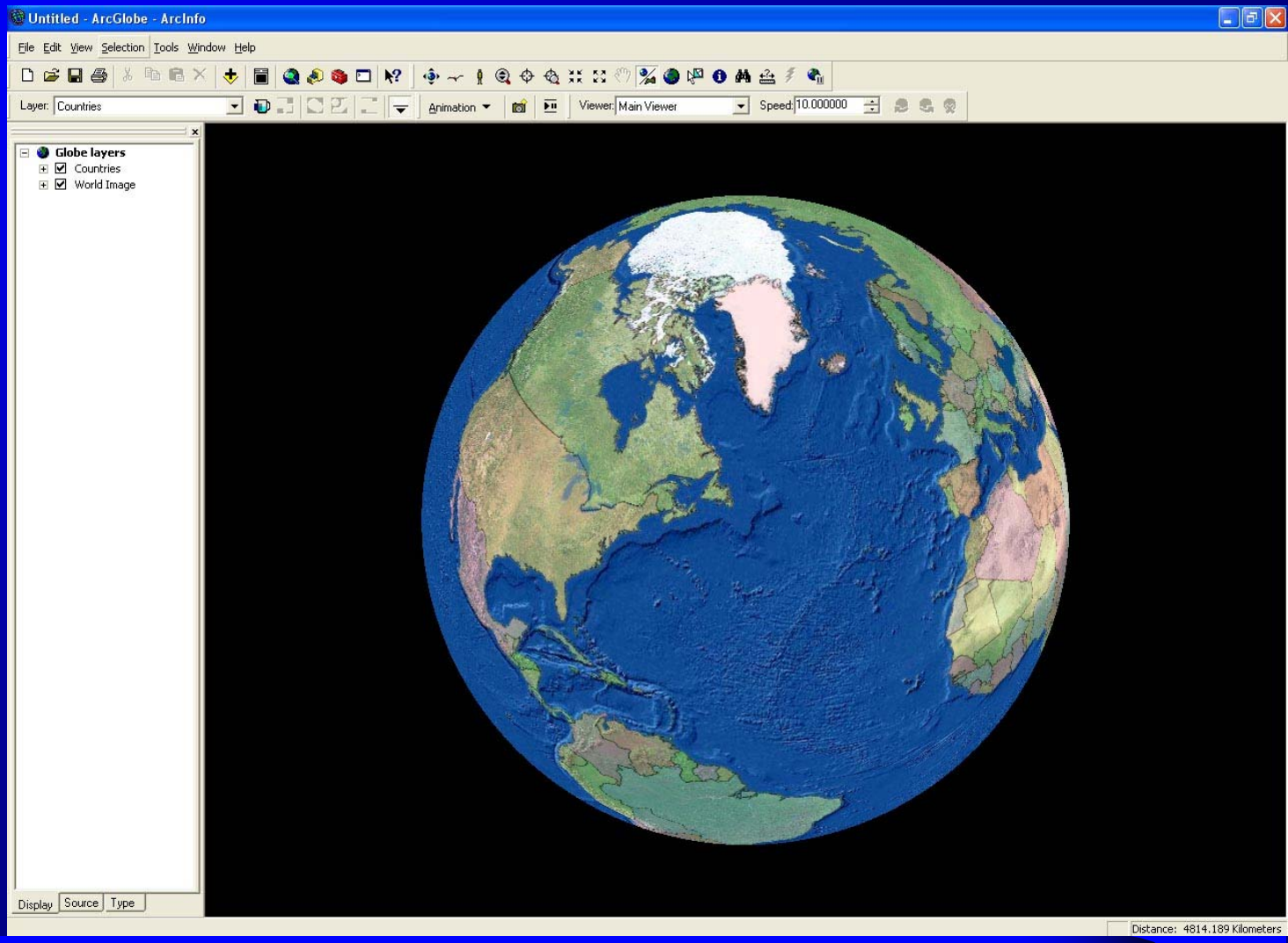
ArcGIS - ArcCatalog

- Manage Files and folders
- Create new shapefiles and geodatabases
- Preview files
- View metadata in format of choice
- create metadata so your data can be understood and shared with others
- Save metadata files as .xml, .txt., .html or .sgml



ArcGlobe - ArcGIS

- View the world as a globe
- 3D effects
- Animated fly-throughs on a globe surface
- Tools for recording
- movies



ArcGIS Extensions

3D Analyst	Network Analyst
ArcScan	Spatial Analyst
Data Interoperability	Survey Analyst
Geostatistical Analyst	Tracking Analyst

http://www.esri.com/software/arcgis/about/desktop_extensions.html

This workshop is introducing the ESRI desktop GIS software suite. For more information about their Server GIS and Mobile GIS products visit: http://www.esri.com/

Google Earth Pro

Features	Google Earth	Google Earth Pro
Performance		Fastest
Print images	1000 pixels	4800 pixels
Integrate GPS data	✓	✓
Ads	✓	Optional
Gain email support		✓
Create premium movies		✓
Import and overlay images	✓	✓
Perform batch geocoding		✓
Measure area		✓
Cost		✓

Available in MIT GIS Lab

Data Management Tips

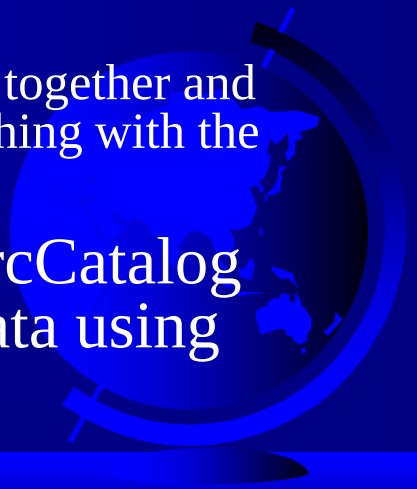
GIS projects tend to generate **many files**, which are frequently **large in size**

- File naming
  - Use file names that represent the file (default names like export_output are not helpful later)
  - Some software programs and tools can have file name constraints like an 8 character limit and no spaces – watch out for this with ESRI ArcToolbox

Data Management Tips

Track your process / keep good notes about

- Data sources – where did you gather your data from and does it have licensing constraints restricting what you can do with it legally?
- Data processing (merging, clipping, joining, and other types of manipulation of the files) – model builder can also help you create visuals of your processes
- What is stored where
  - The GIS project maintains links to the individuals files/ data layers (the data is not embedded in the project itself)
  - GIS formats, like shapefile, have many files that are linked together and must stay together to work (when moving files keep everything with the same name and different extensions together)
- Descriptions of the files you create and use – ArcCatalog has built in tools for creating and editing metadata using standards like FGDC or ISO

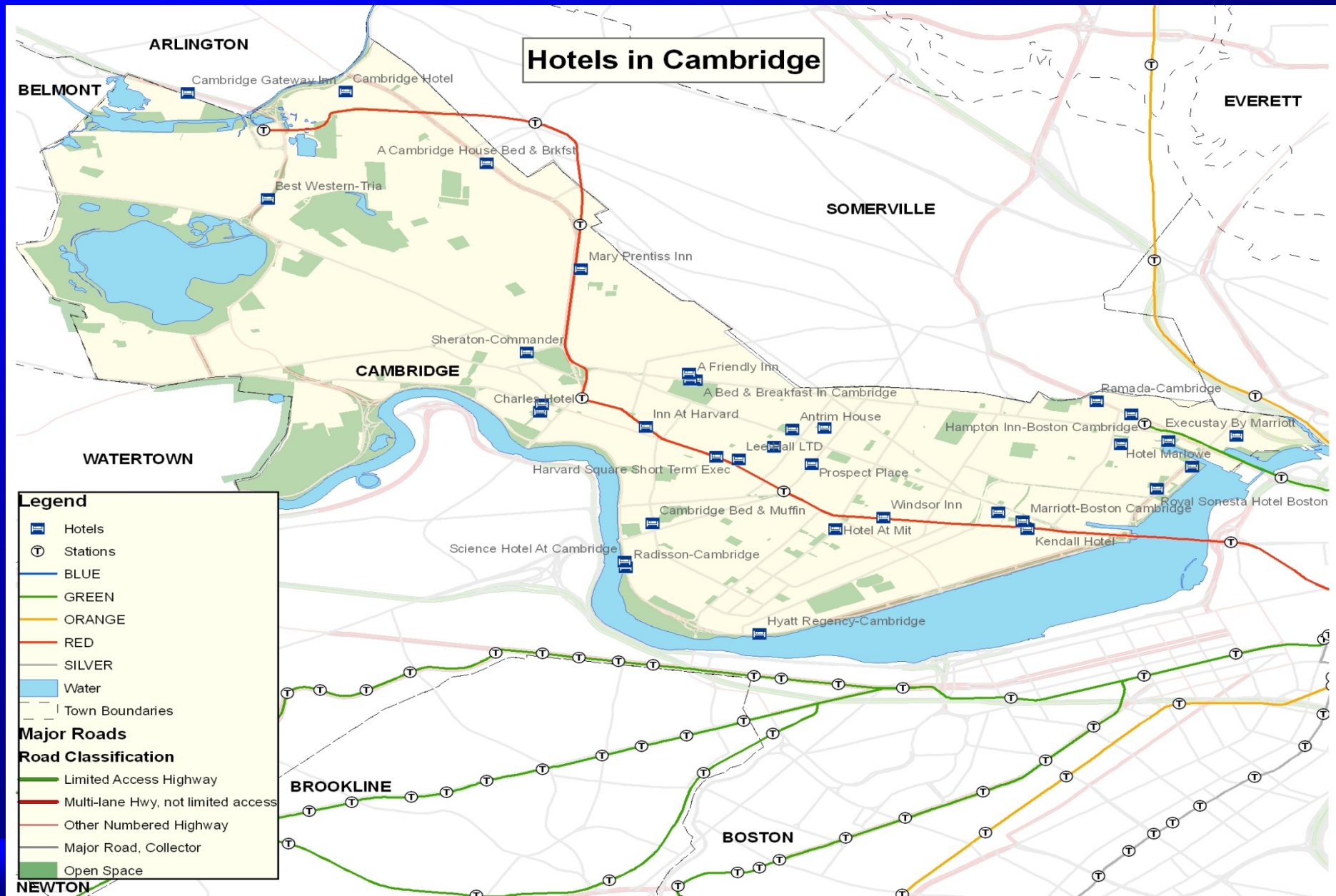


Data Management Tips

Backup your data!

Data Management and Publishing Guide:
http://libraries.mit.edu/guides/subjects/data-management/

Use GIS to: Create Maps

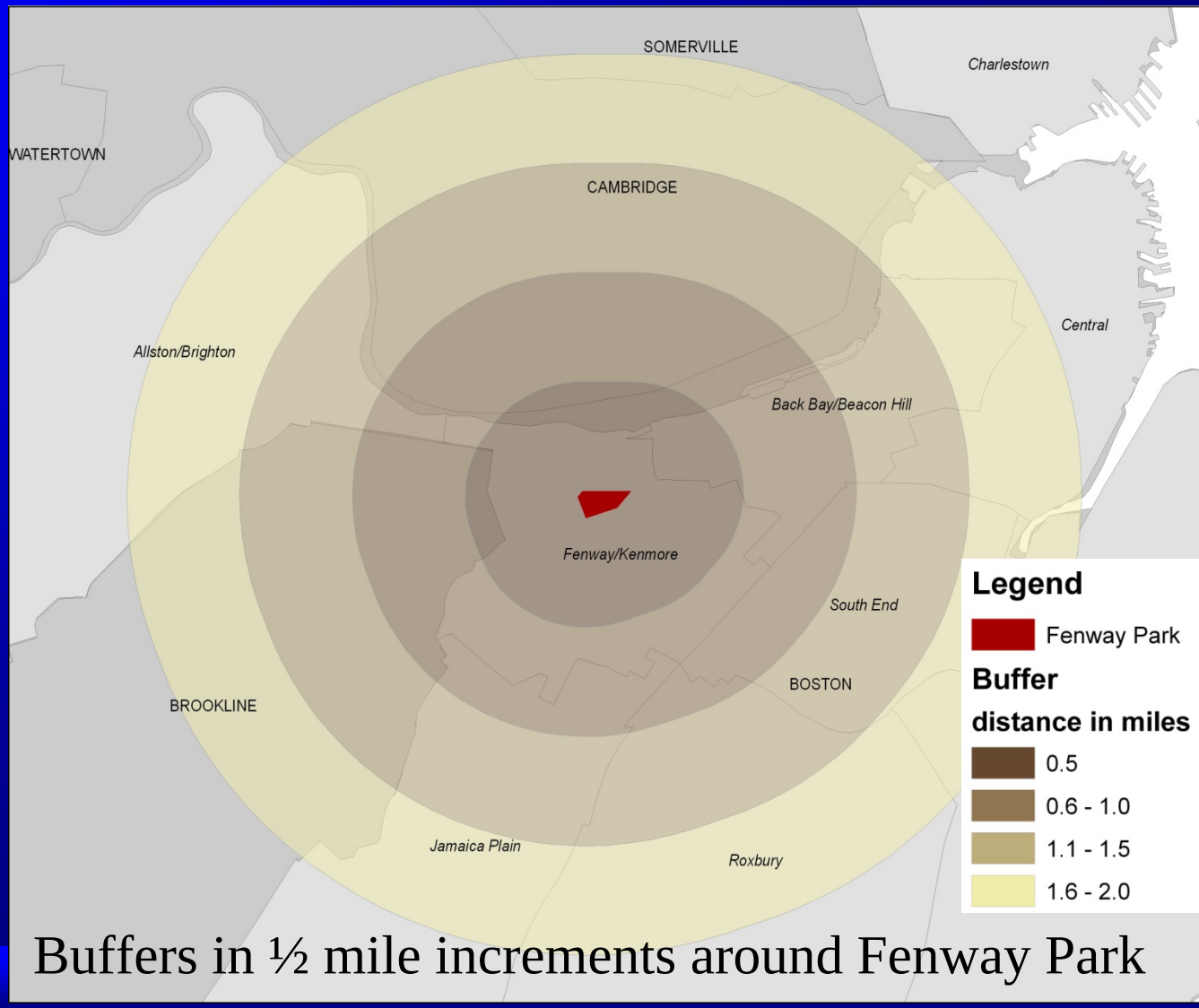


Use GIS to:

Create buffers

Calculate what is

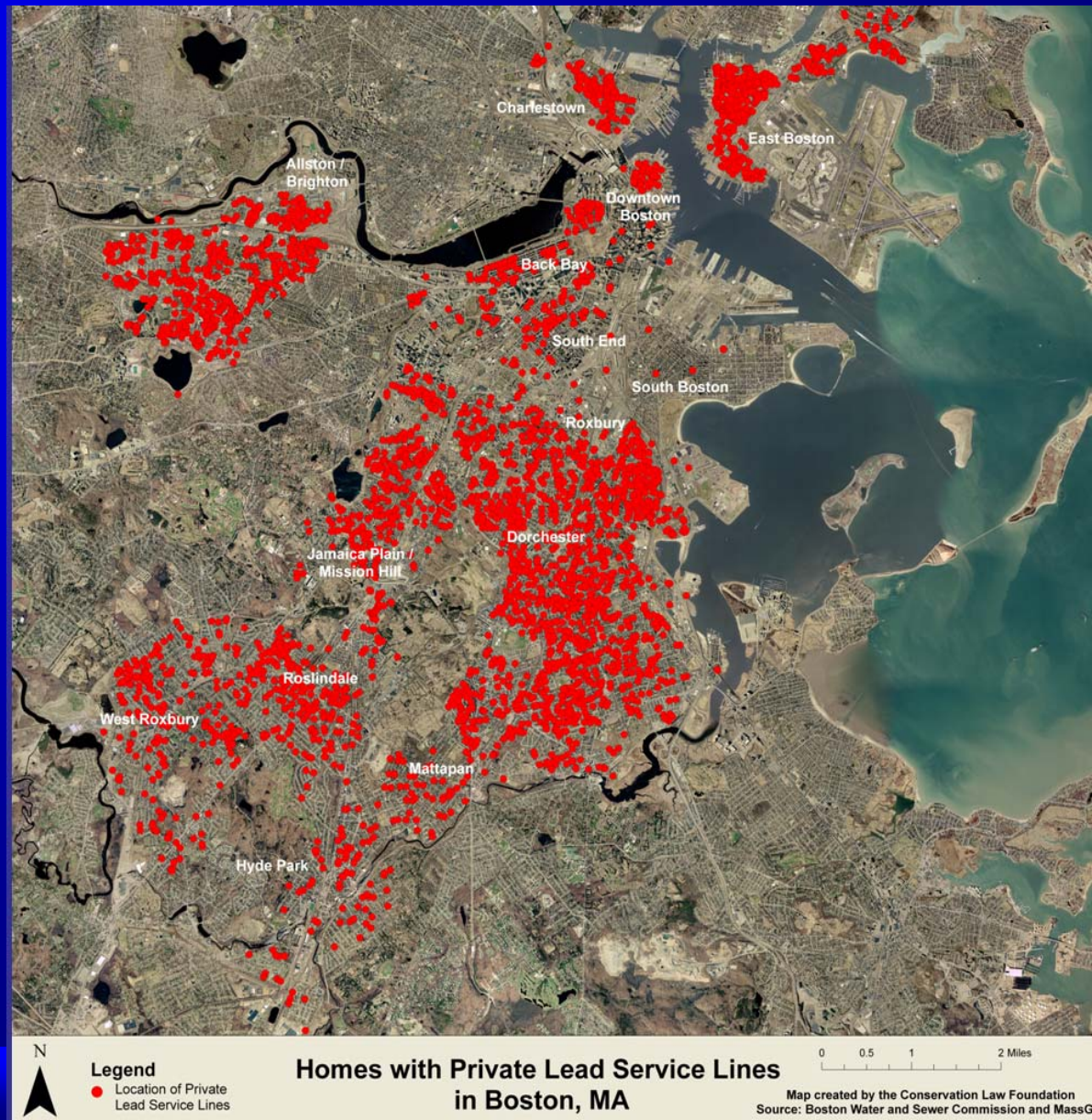
- inside
- outside
- within a certain distance



Buffers in ½ mile increments around Fenway Park

Use GIS to: perform spatial statistics

- Analyzing patterns
- Mapping clusters
- Measuring geographic distributions
- Modeling spatial relationships



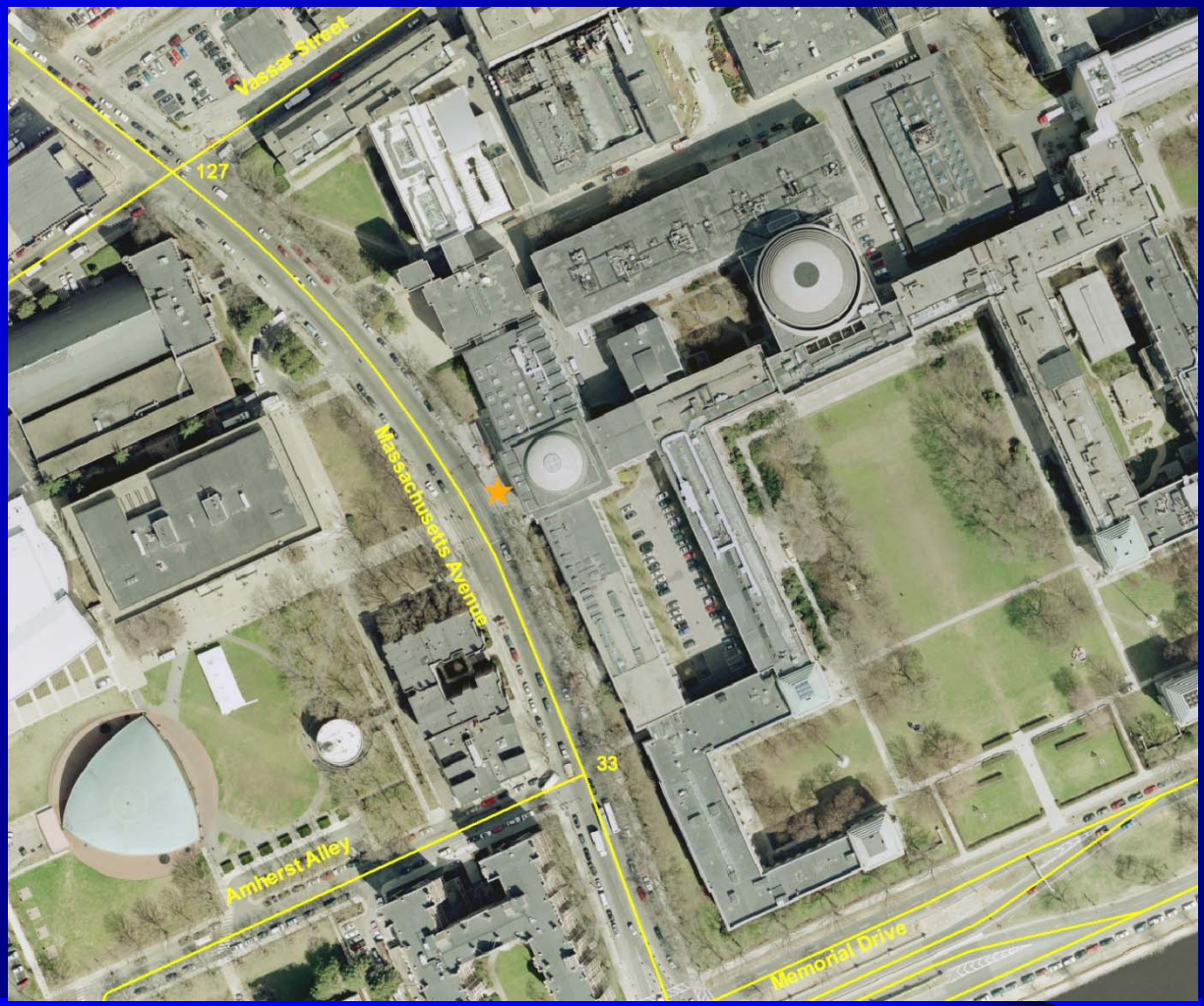
Use GIS to: Map Data

Geocoding Addresses:

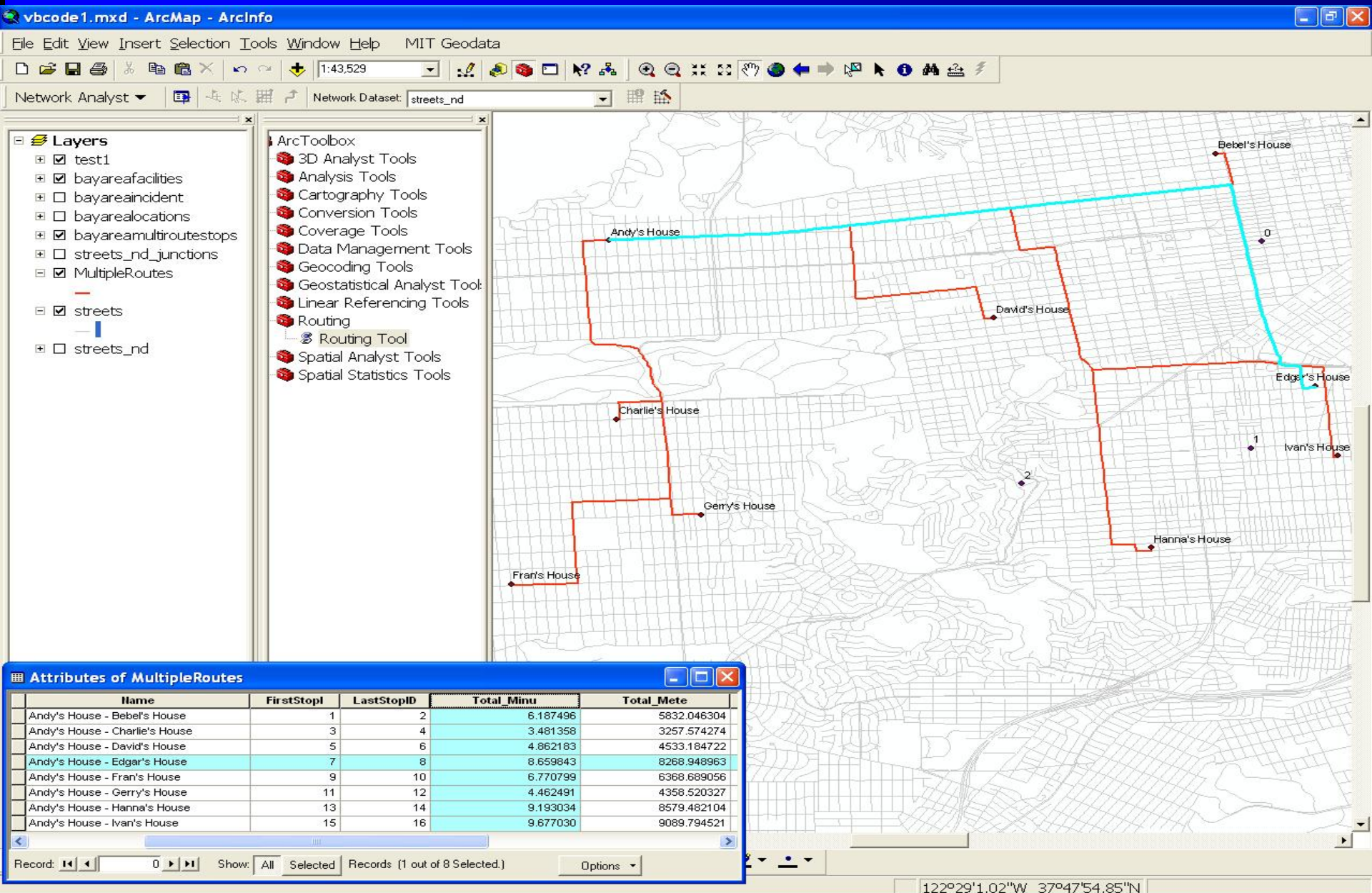
77 Massachusetts Ave.
Cambridge, MA 02139

Add X, Y Data

71 5” 36.45’ W
42 21” 32.75’ N



Use GIS to: do network analysis



Use GIS to:

- Georeference maps and images
- Calculate area and volume
- Perform surface analysis
  - contour
  - slope
  - aspect
  - hillshade
  - Viewshed

http://webhelp.esri.com/arcgisdesktop/9.3/pdf/Geoprocessing_Quick_Guide.pdf

MIT GIS Services

- GIS lab accessible during all Rotch open hours
- Individual GIS assistance (software and data)
  - walk-in help during lab hours: M-TH 12:30-4
  - gishelp@mit.edu – *request help with GIS*
  - mitgis@mit.edu – *listserv for GIS announcements*
- GIS data: Geodata Repository
  (GeoWeb & ArcMap Interface)
- Loan GPS units to MIT community

More Learning Opportunities

- Data Collection workshop
  - 4 sessions + field work
  - late October (after ½ semester GIS module)

- GIS Lab general workshops
  - IAP workshop series (January)
    - *US Census, programming, more*
  - http://libraries.mit.edu/gis/teach/previous-workshops.html

- ESRI virtual campus classes and online help
  - http://libraries.mit.edu/gis/teach/esrivc.html

Rotch Library of Architecture & Planning Tour

- Meet the helpful & friendly **staff** that will help you find, access, use, manage, and cite the information and data you will need for your projects and thesis
- Learn about **image** tools and services
- Tour the **space** with the
  - Art and Architecture books and journals
  - **GIS** lab
  - Maps and atlases
  - Limited access to rare materials

Thursday, 9/2 3-4 pm Rotch Library: 7-238